FINAL
Preliminary Assessment Report Central Oregon Unit Training Equipment Site Redmond, Oregon

Perfluorooctanesulfonic Acid (PFOS) and
Perfluorooctanoic Acid (PFOA) Impacted Sites
ARNG Installations, Nationwide

August 2020

Prepared for:

Army National Guard Headquarters
111 S. George Mason Drive
Arlington, VA 22204

UNCLASSIFIED

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Acronyms and Abbreviations

°F	degrees Fahrenheit
AECOM	AECOM Technical Services, Inc.
AFFF	aqueous film forming foam
amsl	above mean sea level
AOI	area of interest
ARNG	Army National Guard
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COUTES	Central Oregon Unit Training Equipment Site
DEQ	(Oregon) Department of Environmental Quality
EDR^{TM}	Environmental Data Resources^{TM}
FTA	fire training area
NPDES	National Pollutant Discharge Elimination System
OMD	Oregon Military Department
ORARNG	Oregon Army National Guard
OWS	Oil/water separator
PA	Preliminary Assessment
PFAS	per- and poly-fluoroalkyl substances
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
SI	Site Inspection
UCMR3	Unregulated Contaminant Monitoring Rule 3
US	United States
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VSI	Visual Site Inspection

Executive Summary

The Army National Guard (ARNG) is performing Preliminary Assessments (PAs) and Site Inspections (SIs) for Perfluorooctanesulfonic acid (PFOS) and Perfluorooctanoic acid (PFOA) Impacted Sites at ARNG Facilities Nationwide. A PA for per- and polyfluoroalkyl substances (PFAS)-containing materials was completed for the Central Oregon Unit Training Equipment Site (COUTES) (also referred to as the “facility”) in Redmond, Oregon, to assess potential PFAS release areas and exposure pathways to receptors. The COUTES has operated at the Redmond location since 1987 under a fee title ownership with the Oregon Military Department (OMD). Approximately 6.4 acres of the installation area is owned by the City of Redmond and leased to OMD. The COUTES is operated as a maintenance repair facility for OMD vehicles and equipment. No military or firefighting training have ever occurred onsite at the COUTES, with exception for a live firing range which has been inactive since August 2018.

The performance of this PA included the following tasks:

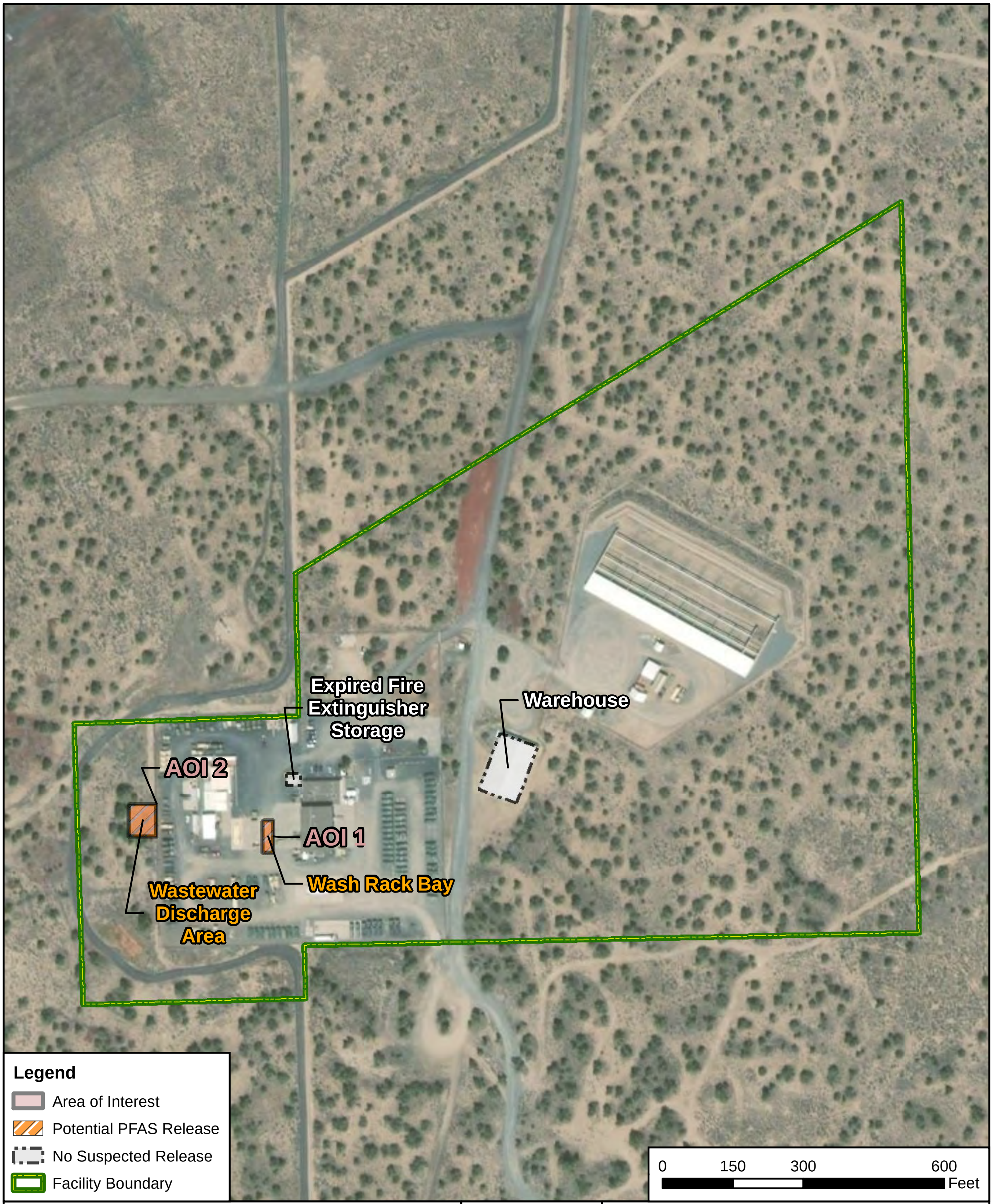
- Reviewed available administrative record documents and Environmental Data Resources, Inc. (EDR)™ report packages to obtain information relevant to potential PFAS releases, such as: drinking water well locations, historical aerial photographs, Sanborn maps, and environmental compliance actions in the area surrounding the facility;
- Conducted a 1-day site visit on 5 October 2018 and completed visual site inspections (VSIs) at locations where PFAS-containing materials were suspected of being stored, used, or disposed;
- Interviewed current COUTES personnel and OMD management during the site visit; and
- Identified Area(s) of Interest (AOIs) and developed a preliminary conceptual site model (CSM) to summarize potential source-pathway-receptor linkages of potential PFAS in soil, groundwater, surface water, and sediment for each AOI.

Two AOIs related to potential PFAS releases were identified at COUTES during the PA. The AOIs are shown on **Figure ES-1** and described in **Table ES-1** below.

Table ES-1: AOIs at the COUTES

Area of Interest	Name	Used by	Potential Release Dates
AOI 1	Wash Rack Bay	OMD	Unknown
AOI 2	Wastewater Discharge Area	OMD	Unknown

Based on potential PFAS release at these AOIs, there is potential for exposure to PFAS contamination in media at or near the facility. The preliminary CSM for COUTES is shown on **Figure ES-2**, which presents the potential receptors and media impacted. Based on the United States Environmental Protection Agency (USEPA) Unregulated Contaminant Monitoring Rule 3 data, it was indicated that no PFAS were detected in a public water system above the USEPA Health Advisory within 20 miles of the facility. PFAS analyses performed in 2016 had method detection limits that were higher than currently achievable. Thus, it is possible that low concentrations of PFAS were not detected during the UCMR3 but might be detected if analyzed today.



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NOTES	Preliminary Assessment for PFAS at Biak COUTES, OR			
REVISED	6/5/2020	GIS BY	MS	6/5/2020
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Base Map: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS,		PM	RG	6/5/2020

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Summary of Findings

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Figure ES-1

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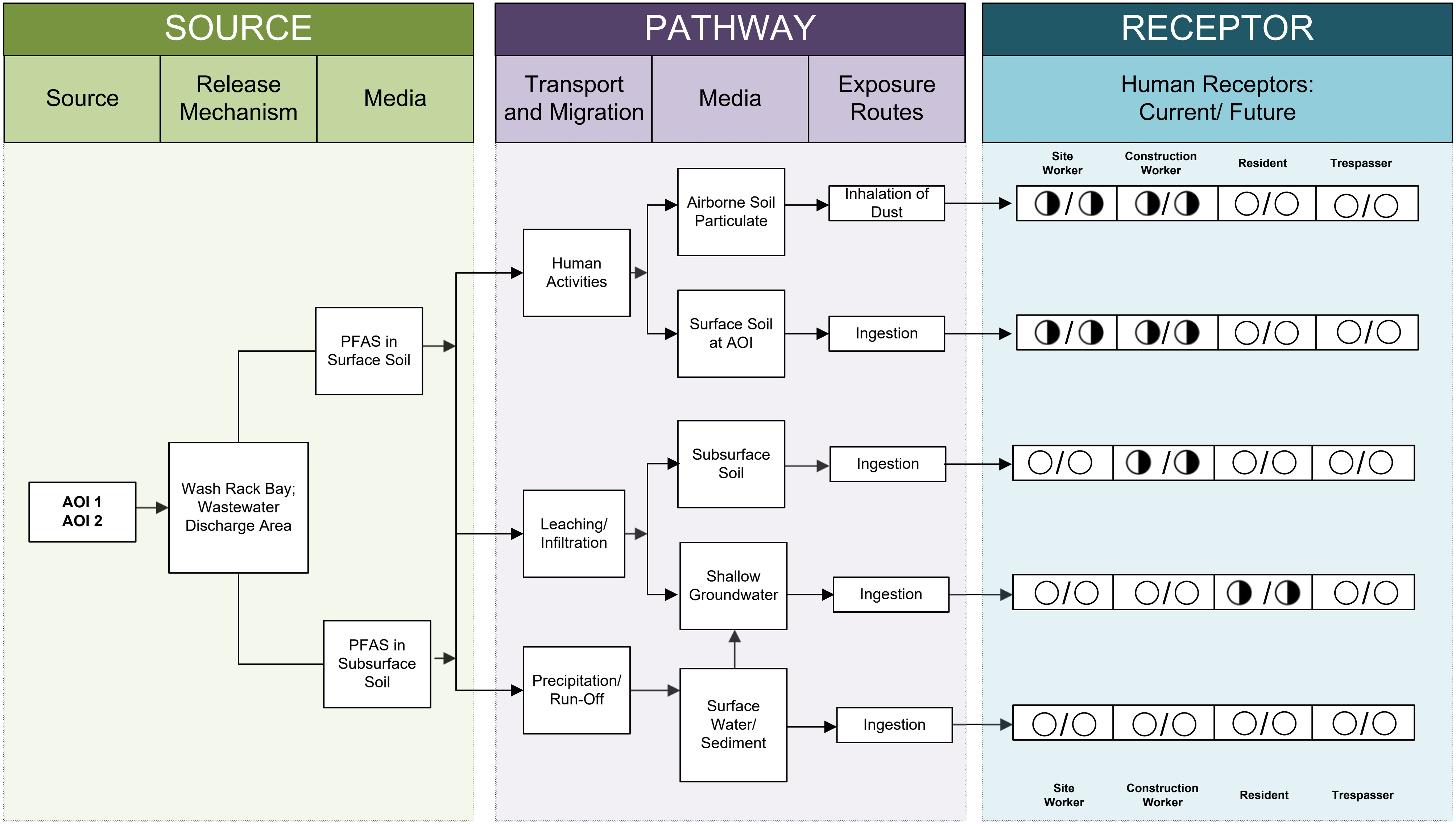


LEGEND

Flow-Chart Stops

Flow-Chart Continues

Partial / Possible Flow

○ Incomplete Pathway

◐ Potentially Complete Pathway

● Complete Pathway

Figure ES-2
Preliminary Conceptual Site Model
COUTES

1. Introduction

1.1 Authority and Purpose

The Army National Guard (ARNG) G9 is the lead agency in performing *Preliminary Assessments (PAs) and Site Inspections (SIs) for Perfluorooctanesulfonic acid (PFOS) and Perfluorooctanoic acid (PFOA) at Impacted Sites at ARNG Facilities Nationwide*. This work is supported by the United States (US) Army Corps of Engineers (USACE) Baltimore District and their contractor AECOM Technical Services, Inc. (AECOM) under Contract Number W912DR-12-D-0014, Task Order W912DR17F0192, issued 11 August 2017.

The ARNG is assessing potential effects on human health related to processes at their facilities that used per- and poly-fluoroalkyl substances (PFAS) (a suite of related chemicals), primarily releases of aqueous film forming foam (AFFF), although other sources of PFAS are possible. In addition, the ARNG is assessing businesses or operations adjacent to the ARNG facility (not under the control of ARNG) that could potentially be responsible for a PFAS release.

PFAS are classified as emerging environmental contaminants that are garnering increasing regulatory interest due to their potential risks to human health and the environment. PFAS formulations contain highly diverse mixtures of compounds. Thus, the fate of these PFAS compounds in the environment will vary. The regulatory framework at both federal and state levels continues to evolve. The US Environmental Protection Agency (USEPA) issued Drinking Water Health Advisories for PFOA and PFOS in May 2016, but there are currently no promulgated national standards regulating PFAS in drinking water. In the absence of federal maximum contaminant levels, some states have adopted their own drinking water standards for PFAS. The Oregon Department of Environmental Quality has Pollutant Initiation Levels for PFAS/PFOA, which are not water quality standards (DEQ, 2017). According to OAR 340-045-0100, only facilities that operate under National Pollution Discharge Elimination System (NPDES) and Water Pollution Control Facility permits in Oregon are required to analyze effluent for PFAS/PFOA and report concentrations that exceed the Initiation Level.

This report presents findings of a PA for PFAS-containing materials for the Central Oregon Unit Training Equipment Site (COUTES) (also referred to as the “facility”) in Redmond, Oregon, in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, the National Oil and Hazardous Substances Pollution Contingency Plan (40 Code of Federal Regulations Part 300), and Army requirements and guidance.

This PA documents the known locations where PFAS may have been released into the environment at the COUTES. The term PFAS will be used throughout this report to encompass all PFAS chemicals being evaluated, including PFOS and PFOA, which are key components of AFFF.

1.2 Preliminary Assessment Methods

The performance of this PA included the following tasks:

- Reviewed available administrative record documents and Environmental Data Resources, Inc. (EDR)™ report packages to obtain information relevant to potential PFAS releases, such as: drinking water well locations, historical aerial photographs, Sanborn maps, and environmental compliance actions in the area surrounding the facility;

- Conducted a 1-day site visit on 5 October 2018 and completed visual site inspections (VSIs) at locations where PFAS-containing materials were suspected of being stored, used, or disposed;
- Interviewed current COUTES personnel and OMD management during the site visit; and
- Identified Area(s) of Interest (AOIs) and developed a preliminary conceptual site model (CSM) to summarize potential source-pathway-receptor linkages of potential PFAS in soil, groundwater, surface water, and sediment for each AOI.

1.3 Report Organization

This report has been prepared in accordance with the USEPA *Guidance for Performing Preliminary Assessments under CERCLA* (USEPA, 1991). The report sections and descriptions of each are:

- **Section 1** – **Introduction:** identifies the project purpose and authority and describes the facility location, environmental setting, and methods used to complete the PA.
- **Section 2** – **Fire Training Areas:** describes the FTAs at the facility identified during the site visit.
- **Section 3** – **Non-Fire Training Areas:** describes other locations of potential PFAS releases at the facility identified during the site visit.
- **Section 4** – **Emergency Response Areas:** describes areas of potential PFAS release at the facility, specifically in response to emergency situations.
- **Section 5** – **Adjacent Off-Site Sources:** describes sources of potential PFAS release adjacent to the facility that are not under the control of ARNG.
- **Section 6** – **Preliminary Conceptual Site Model:** describes the pathways of potential PFAS transport and receptors at each area of interest (AOI).
- **Section 7** – **Conclusions:** summarizes the data findings and presents the conclusions of the PA.
- **Section 8** – **References:** provides the references used to develop this document.
- **Appendix A** – Data Resources
- **Appendix B** – Preliminary Assessment Documentation
- **Appendix C** – Photographic Log

1.4 Facility Location and Description

The COUTES is in Redmond, Deschutes County, less than 2 miles east of Redmond’s city center. The facility is less than 0.5-miles south of Highway 126 and less than 0.25 miles east of the Redmond Airport (**Figure 1-1**). The facility is occupied and operated by the Oregon Army National Guard as a maintenance and repair facility, encompassing 35.5 acres (Deschutes County, 2018). No firefighting training or AFFF use has historically occurred or currently occurs onsite.

The present-day COUTES property is owned by the federal government, administered by the USACE, licensing use to the OMD since 1987. The western-most portion of the western installation area (approximately 6.4 acres west of the maintenance building) is owned by the City of Redmond and leased to OMD since 1973 (OMD, 2016; Deschutes County, 2018). The COUTES is within the Biak Training Center boundary area, which is comprised of 4,300-acres owned by the Bureau of Land Management and leased to the OMD. The COUTES is comprised of two separate areas. Primary facility operations occur in the western portion of the facility, which includes the maintenance building, wash rack bay, and a warehouse. Secondary facility operations occur in the eastern portion of the facility, which includes an inactive firing range and a warehouse structure for storing miscellaneous items and equipment. Access to the facility is not controlled. The facility is connected to one drinking water well that receives no treatment and a septic system that discharges to an adjacent leach field. Wastewater from the wash rack bay is discharged to the west of the facility boundary via irrigation, which is permitted under a Water Pollution Control Facility NPDES permit since 2001 (type GEN17B, Water Quality File No. 111416) (DEQ, 2019).

Based on review of historical aerial photographs, development of the western portion of the facility appears by 1980; development of the eastern portion of the facility appears by 1994 with the firing range; development of the maintenance building in the western portion of the facility appears by 1994; and development of the warehouse in the eastern portion of the facility area appears by 2006. The facility appears to be in similar configuration as observed during the site visit since the 2006 aerial photograph (EDR, 2018a; Google Earth, 2018).

1.5 Facility Environmental Setting

The COUTES is in the Deschutes Columbia Plateau geologic province of Oregon (DEQ, 2013; USDI, 2018). The facility is bordered on all four boundaries by undeveloped land. The property boundary for the Redmond Airport is located immediately adjacent to the west of the facility (the runway is located approximately 1,200 feet to the northwest (Google Earth, 2018; Deschutes County, 2018).

The facility is comprised mostly of undeveloped, vegetated land underlain by historic volcanic lava flow beds. The areas of the facility that are paved include the road to enter/exit the facility and the areas surrounding the buildings in the western installation area and the warehouse and firing range in the eastern installation area. The paved areas are primarily flat. In both directions, from west to east and north to south, elevation at the facility ranges from approximately 3,050 and increases to 3,070 feet above mean sea level (AMSL). Elevation throughout the facility averages 3,060 feet AMSL. Topography at the site follows a northwest gradient (Google Earth, 2018; EDR, 2018b).

1.5.1 Geology

The COUTES is in a geologic area characterized as basalt and basaltic andesite of the Pleistocene to Holocene ages. This geologic feature occurs primarily along the crest of the Cascade Range (located to the west of the facility) (USGS, 2018a). These basaltic lava flows are the most widespread types of surface rocks in the region, with the oldest basalt lava flows exposed west of the Deschutes River (west of the facility). Vents from the lava flows are dispersed throughout the region as lava and cinder cones. The lava terrain covers the region as generally thin sheets of pahoehoe basalt associated with historic fissure eruptions where the surface appears ropy with depressions, known as “Lava Badlands.” The lava flows were estimated to extend from the land surface to 50 to 100 feet below ground surface (bgs). Lava Badlands consist of a lava tube system, indicative of a lateral spread of lava. The Redmond Caves is one such lava tube system, approximately four miles to the northwest of the COUTES. (DOGAMI, 1976; Google Earth, 2018).

The COUTES is underlain by volcanic deposits of the Quaternary system of the Cenozoic era (EDR, 2018b). These volcanic deposits constitute the second major composite stratigraphic unit in the region, which is reported extending to depths over 2,000 feet in some areas. This composition is comprised of lava flows, domes, vent deposits, pyroclastic deposits, and volcanic sediments (USGS, 2001). The volcanic rocks consist of ash and cinders while the sedimentary rocks consist of semi-consolidated sand and gravel eroded from volcanic rocks (USGS, 1994, 2018b).

1.5.2 Hydrogeology

Soils beneath the COUTES consist primarily of Deschutes-Stukel complex (35B, 0 to 8 percent slope) in the northern and western areas of the installation boundary and Stukel-Rock outcrop-Deschutes complex (142B, 0 to 8 percent slope) south of the installation boundary (USDA, 2018). Both soil series consist of shallow, well drained soils with moderately rapid permeability located in lava plains that formed in ash (USDA, 1999). The Deschutes complex is characterized as sandy loam in the top 31 inches, followed by basalt at 31 inches. The Stukel complex is characterized as sandy and cobbly sandy loam in the top 11 inches, followed by gravelly sandy loam to 18 inches bgs, and basalt at 18 inches bgs. Bedrock of the Deschutes series is reported at 20 to 40 inches bgs while bedrock of the Stukel series is reported at 10 to 20 inches bgs (USDA, 1999).

The COUTES is above the Deschutes Formation, which is the principle aquifer in the Upper Deschutes Basin. Because of the large amount of rainfall that occurs, the Cascade Range is the principal groundwater recharge area for the Upper Deschutes Basin. Groundwater from the Cascade Range flows through the permeable volcanic rock towards the east into the Upper Deschutes Basin, where half of the volume discharges to streams and the other half of the volume flows through the subsurface of the Deschutes Formation, eventually discharging to streams. Groundwater discharge to streams is the principle mechanism of groundwater losses in the system where stream elevation is lower than the groundwater table. Groundwater discharges to streams occur west of the COUTES, surrounding the confluence of the Deschutes River (west of Bend). The Deschutes River maintains substantial flow during dry periods. Stream discharge varies by location and seasonal precipitation. Regionally, the water table fluctuates in association with recharge. Infiltration of precipitation in the region occurs from rainfall, snowmelt, canal and stream leaks, and irrigation water. The United States Geological Survey (USGS) estimated annual recharge from infiltration of precipitation in the area surrounding the facility ranging from 0 to 1.5 inches. Recharge averages 35 to 40 percent of the annual precipitation measured throughout the Upper Deschutes Basin (USGS, 2001).

Groundwater flow would generally follow the topographic gradient to the northwest. Groundwater flow may vary in localized areas of groundwater recharging to surface water. Groundwater flow at the facility cannot be determined without conducting a site-specific assessment. The COUTES obtains drinking water from one onsite water supply well located in the central portion of the facility, at the northeast corner of the maintenance building (Well #59860) (**Figure 1-2**). The geographic coordinates of the water well are: 44°15'20.955"N, 121°7'59.358"W. The well was completed in 2013 at a depth of 600 feet bgs and depth to groundwater was reported at 341 feet bgs (OWRD, 2018). Prior to the use of this well, the COUTES obtained drinking water from Well #3954, which was located east of the maintenance building and abandoned in 2018. The geographic coordinates of the abandoned water well were: 44°15'20.96"N and 121° 7'59.69"W. The abandoned well was completed in May 1979 at a depth of 425 feet bgs; depth to water was reported at 390 feet bgs (OWRD, 2018). The Redmond Water Department has several drinking water source areas with public groundwater systems immediately to the west, southwest, and north of the COUTES (DEQ, 2018a). The nearest USGS monitoring well is located approximately 8 miles to the east of the facility (Site No. CROO0001954). The geographic coordinates are: 44°14'41.28"N and 120°58'3.72"W. This well was drilled to 450 feet bgs and depth to groundwater was measured ranging from 245 to 315 feet bgs (measured between 1981 and 2018) (**Figure 1-2**) (USGS, 2018b).

Based on USEPA's Unregulated Contaminant Monitoring Rule 3 (UCMR3) data (samples collected between 2013 and 2016), no PFAS were detected in a public water system above USEPA's lifetime Health Advisories (HAs) within 20 miles of the facility, including the cities of Redmond and Bend, which were sampled in 2013 and 2014 (USEPA, 2017a). PFAS analyses performed in 2016 had method detection limits that were higher than currently achievable. Thus, it is possible that low concentrations of PFAS were not detected during the UCMR3 data analyses, but might be detected if analyzed today.

1.5.3 Hydrology

The COUTES is in the North Unit Main Canal subwatershed (HUC 12), which is within the Lone Pine Creek-Crooked River (HUC 10) watershed of the Lower Crooked subbasin (HUC 8), of the Deschutes Basin (HUC 6) (**Figure 1-3**) (USEPA, 2017b). No surface water features are located at the facility. The nearest offsite surface waterbody is the North Unit Main Canal less than 0.5 miles to the east of the facility, flowing northeast/southwest. The Deschutes River is located approximately 5 miles west of COUTES, flowing northeast/southwest, and is a major tributary to the Columbia River (located along the Oregon-Washington boarder) (DEQ, 2018b). No wetlands are located at the facility (USFS, 2018).

The facility is primarily unpaved; paved areas include the roadway and the parking areas surrounding the buildings. Surface stormwater runoff from paved areas flows into stormwater catch basins located in the western installation area (OMD, 2018). Stormwater runoff to unpaved areas infiltrates the soil. Surface water runoff at COUTES would only occur during heavy precipitation events where precipitation exceeds the infiltration rate of soil.

1.5.4 Climate

Climate in the Deschutes Basin is considered semiarid: moderate with cool, wet winters and warm, dry summers. The climate is driven by air masses developing in the Pacific Ocean (approximately 150 miles west of the COUTES) and moving east over the Cascade Range (approximately 35 miles west of the COUTES), dropping up to 200 inches of precipitation (rainfall and snow) annually (mostly snow during the winter). The Deschutes Basin's climate experiences annual and long-term variability. Precipitation decreases east of the Cascade Range significantly (USDA, 1966; USGS, 2001).

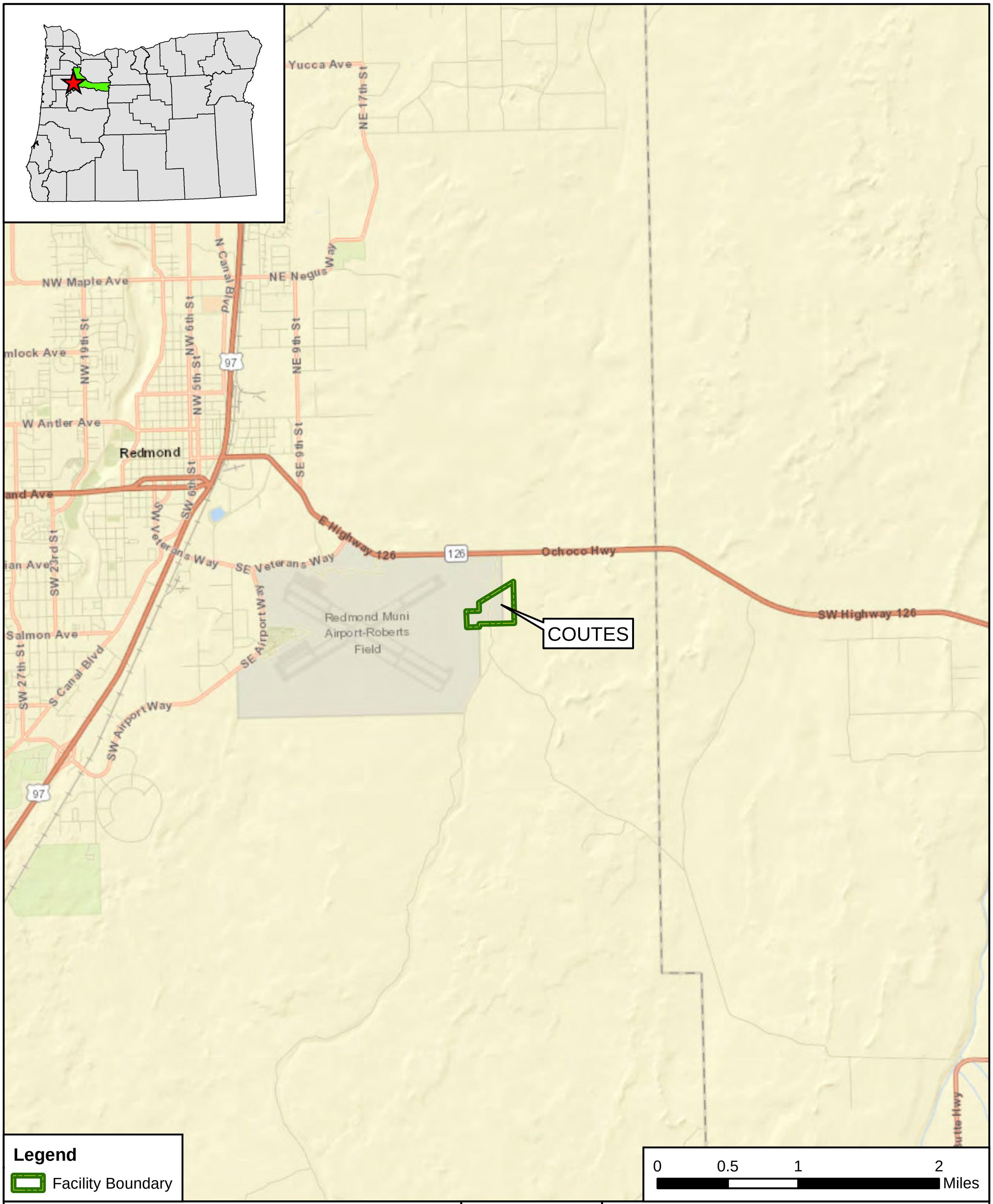
Weather data recorded at the Redmond Airport weather station from 1990 to 2018 (Station OR USW00024230), located less than 1,000 feet to the west of the COUTES, reported the following climatic measurements: average annual precipitation of 8 inches, average annual snowfall of 9 inches, and average temperature of 49 degrees Fahrenheit (^{o}F) (max of 86 ^{o}F) (NOAA, 2018).

1.5.5 Current and Future Land Use

The nearest urban area is the City of Redmond, less than 2 miles west of the facility. The Redmond Airport is immediately adjacent to the west of the facility. Highway 126 is located less than 0.25 miles north of the facility, which travels east/west from Redmond (west) to Prineville (east). Land use surrounding the facility is primarily agricultural and undeveloped. The facility is zoned as Rural Industrial (Deschutes County, 2018). Land surrounding the facility is zoned as Exclusive Farm Use Alfalfa (EFUAL – Alfalfa Subzone) to the north, east, and south and as Airport Limited to the west. Properties further west and northwest of the facility are zoned as industrial (Deschutes County, 2018).

According to the 2017 US Census, the estimated population of Redmond was 30,011 (Census, 2017). Based on the population estimates, Redmond's population has increased by nearly 3,800 since 2010 (Census, 2017). The population of Redmond is expected to increase to 45,724 by 2025 (Deschutes County, 2011). Redmond's urban growth boundary was amended in

2019 to cover over 2,000 acres of additional land for residential and industrial land expansion, in addition to the Military Department's National Guard Armory (Deschutes County, 2011a). Redmond's urban growth boundary is located approximately 2 miles to the northwest of the facility, and is not expected to encroach upon the facility (City of Redmond, 2020). Plans for the future use of COUTES are unknown. According to the Deschutes County *Comprehensive Plan*, land zoned as Exclusive Farm Use shall be preserved in order to protect farmlands (Deschutes County, 2011b). Therefore, future land development of the facility and adjacent lands are not expected to be developed for other purposes as currently zoned).



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Base Map: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI,		PM	RG	6/5/2020

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Facility Location

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Figure 1-1

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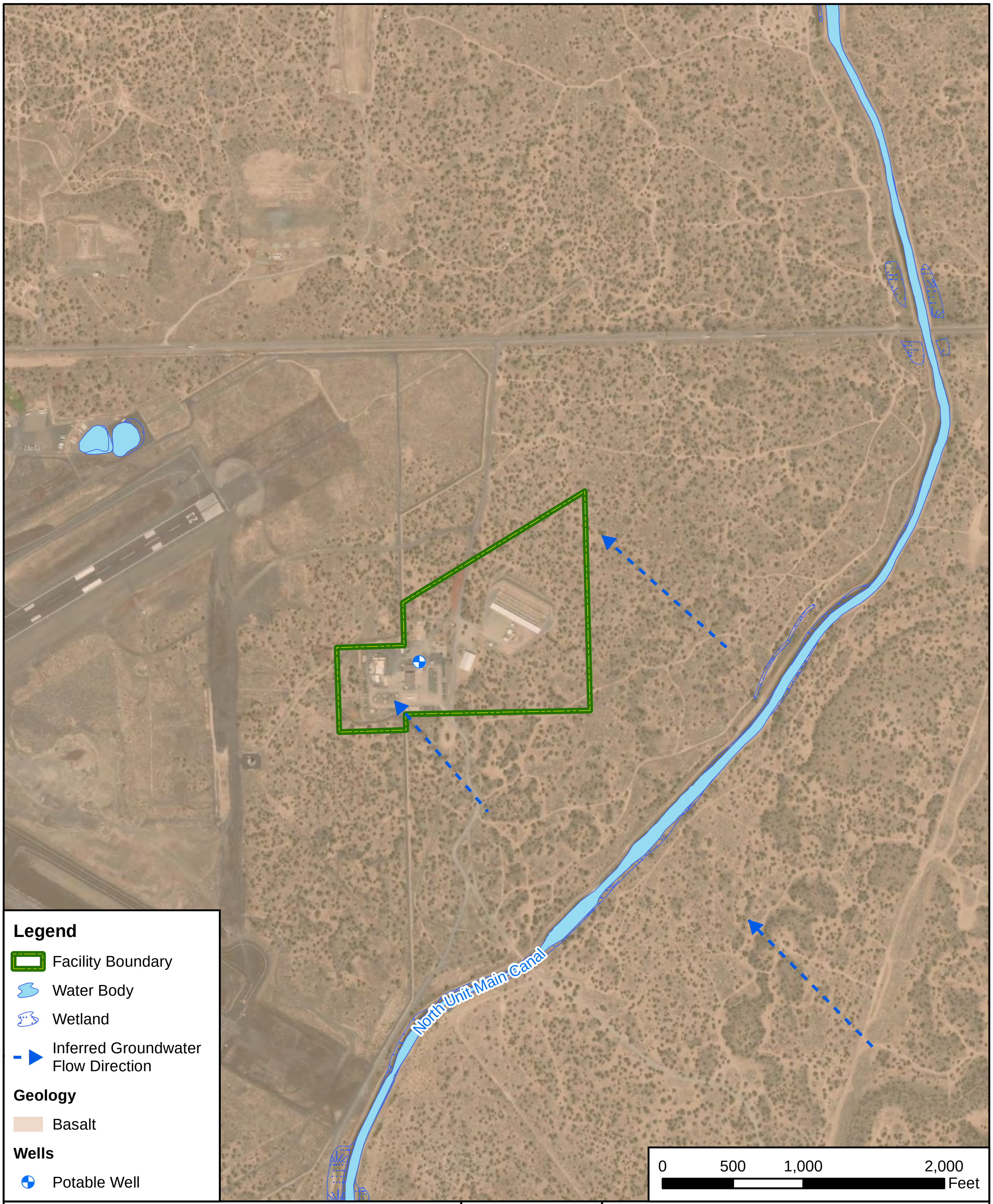

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Groundwater Features

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Figure 1-2

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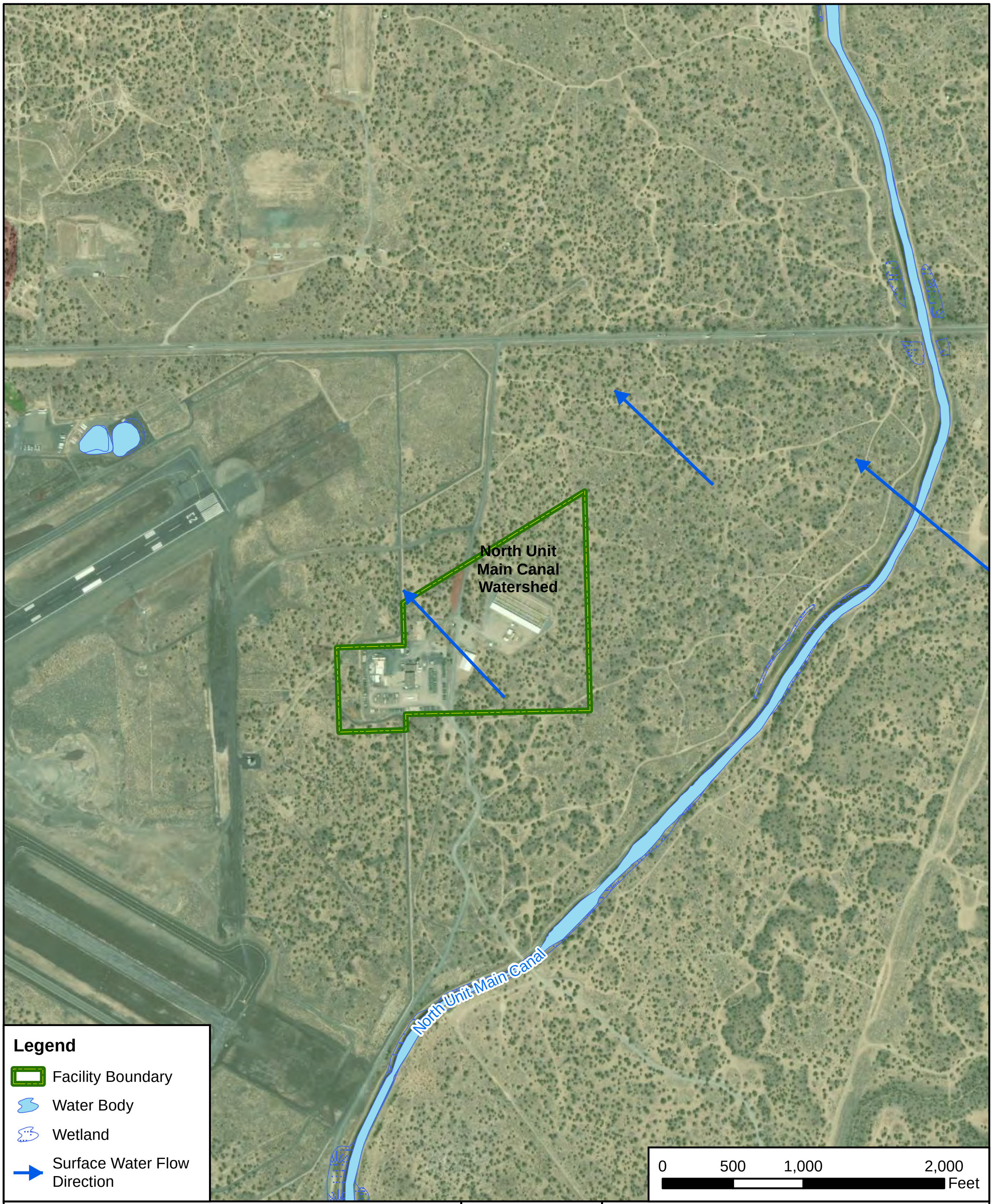

Surface Water Features

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Base Map: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS,		PM	RG	6/5/2020

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Figure 1-3

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2. Fire Training Areas

No FTAs where PFAS-containing materials was potentially released were identified at the COUTES during the PA. Firefighting support for structural fires is coordinated with the City of Redmond Fire Department using fire trucks that contain only water. No prescribed burns are reported to occur at the COUTES. No off-Post FTAs are reported to exist. Interview records appear in **Appendix B**.

3. Non-Fire Training Areas

In addition to FTAs, the PA evaluated areas where PFAS-containing materials may have been broadly used, stored, or disposed. This may include buildings with fire suppression systems, paint booths, AFFF storage areas, and areas of compliance demonstrations. Information on these features obtained during the PA are included in **Appendices A** and **B**. Four non-FTAs were identified during the PA. Descriptions are presented below and shown on **Figure 3-1**. Photographs of the non-FTAs are included in the Photographic Log (**Appendix C**).

No non-FTAs were identified at the COUTES during the PA. Interview records appear in **Appendix B**.

3.1 Fire Suppression Systems

The COUTES Maintenance Supervisor stated the facility is not equipped with a fire suppression system. During the site visit, no fire suppression systems were observed in the maintenance building or the warehouse structure at the facility.

3.2 Expired Extinguisher Storage

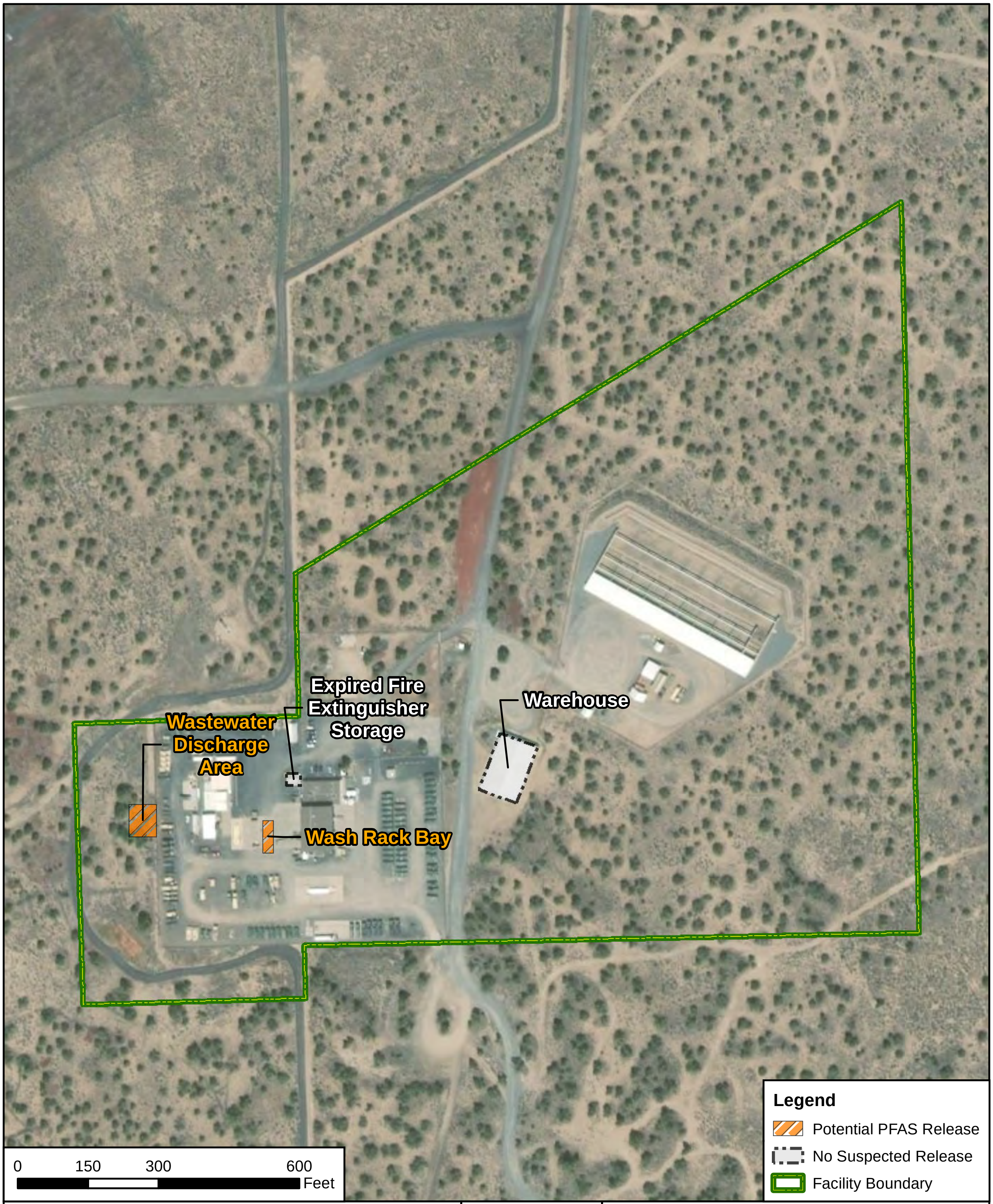
Numerous dry chemical, carbon dioxide, and Purple-K agent fire extinguishers (non-AFFF and non-PFAS-containing) were observed throughout the facility, at both interior and exterior areas. Fire extinguishers observed were either currently active or expired and stored in cages or a large cardboard box. Cages (with expired fire extinguishers) were observed at the exterior of the northwestern corner of the maintenance building and inside the warehouse. A cardboard box (with expired fire extinguishers) was observed at the exterior of the northwestern corner of the maintenance building. Active fire extinguishers were observed at the interior of the maintenance building and on vehicles. Photographs of non-PFAS-containing fire extinguishers observed at the COUTES are included in the Photographic Log (**Appendix C**).

3.3 Wash Rack Bay

An uncovered wash rack bay is located at the facility, along the eastern exterior of the oil/water separator (OWS) building, west of the maintenance hangar. According to interviewed personnel, facility equipment and vehicles, including OMD fire trucks, are washed in this area. The fire trucks are washed only during the summer months and hoses are not flushed. According to interviewed OMD personnel, the OMD fire trucks have not historically used or currently contain AFFF. The duration of the facility’s use of the wash rack, in addition to the potential historical presence of AFFF contained in OMD fire trucks, is not known.

3.4 Wastewater Discharge Area

Wastewater from the wash rack bay is discharged to the west of the facility boundary, along the western side of the facility fencing, approximately 200 feet to the west and downgradient of the wash rack bay. This discharge area is unpaved with a natural vegetative cover. Wastewater from the wash rack bay, which consists of wash water and cleaning detergents is discharged via irrigation, which is permitted under a Water Pollution Control Facility NPDES permit since 2001 (type GEN17B, Water Quality File No. 111416) (DEQ, 2019). The duration of the facility’s use of the wash rack, in addition to the potential historical presence of AFFF contained in OMD fire trucks, is not known.



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Non-Fire Training Areas

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Figure 3-1

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4. Emergency Response Areas

Based on interviews conducted with facility personnel, no emergency response actions using AFFF has occurred at the COUTES. According to the Site Training Manager, no rotary-winged or other aircraft crashes have been reported. Coordination of firefighting support via water trucks for structural fires is made with the City of Redmond Fire Department, but there has been no need for responses at the facility as of the date of the PA interviews (**Appendix B**).

5. Adjacent Sources

No potential off-Post sources of PFAS contamination were identified during the PA. Interview records appear in **Appendix B**. Based on interviews conducted with facility personnel and review of Oregon Department of Environmental Quality's *Facility Profiler Lite* and *Environmental Cleanup Site Information (ECSI)* databases, and EPA's *National Priority List and Superfund Alternative Approach Sites* database, there were no historic or currently active private or municipal wastewater treatment plants, historic or currently active landfills, historic or currently active electrical maintenance or chrome plating shops, or Superfund Sites located in the vicinity of the COUTES (DEQ, 2018c, 2018d; USEPA, 2018).

6. Conceptual Site Model

Based on the PA findings from interviews with facility personnel, VSI observations, and online research, two potential release areas were identified as AOIs at the COUTES. The AOI locations are shown on **Figure 6-1**.

The following section describes the CSM components and the specific preliminary CSM developed for the AOIs. The CSM identifies the three components necessary for a potentially complete exposure pathway: (1) source, (2) pathway, (3) receptor. If any of these elements are missing, the pathway is considered incomplete. The preliminary CSM for AOI 1 is shown in **Figure 6-2**.

6.1 AOI 1: Wash Rack Bay

AOI 1 is at the wash rack bay, which is located in the central portion of the main operational facility area, along the eastern exterior of the OWS building (west of the maintenance building). There are no known or documented releases of PFAS at AOI 1. The wash rack bay and surrounding area are paved, associated with the OWS building. The wash rack bay is used to wash facility equipment and vehicles, including OMD fire trucks. According to interviewed personnel, fire trucks are only washed during the summer months and hoses are not flushed out. According to interviewees, fire trucks that OMD uses do not contain AFFF. The concrete of the wash rack bay appeared to be generally in good condition, with exception for some cracks observed. The wash rack bay is equipped with catch basins. Wastewater from the wash rack bay is discharged to the west of the facility boundary via irrigation, which is permitted under a Water Pollution Control Facility NPDES permit since 2001 (type GEN17B, Water Quality File No. 111416) (DEQ, 2019). The duration of the facility's use of the wash rack, in addition to the potential historical presence of AFFF contained in the fire trucks that were washed, is not known.

PFAS are water soluble and can migrate readily from soil to groundwater via leaching. Based on the observed cracks in the concrete and the presence of below-ground catch basins, and the potential for the fire trucks to have contained AFFF, it is possible that PFAS migrated from the surface soil at AOI 1 to groundwater via leaching. Based on visual observations conducted during the site visit and online research, no surface water features or wetlands are located within AOI 1 or the immediate surrounding area downgradient of AOI 1 (USFS, 2018). Precipitation infiltrating AOI 1 (via cracks in the concrete and the catch basins) may cause the migration of PFAS from surface and subsurface soil to groundwater, which is estimated to be within 340 feet bgs (Section 1.5.2).

Groundwater flow typically follows the natural topographical gradient. Around AOI 1, subsurface flow is generally to the northwest. One onsite drinking water well is approximately 200 feet to the northeast and cross-gradient of AOI 1. Public drinking water supplies of the Redmond Water Department are found immediately to the west, southwest, and north of the COUTES, generally downgradient of AOI 1 (DEQ, 2018a). Therefore, the exposure pathway for groundwater via ingestion is potentially complete for off-facility residents.

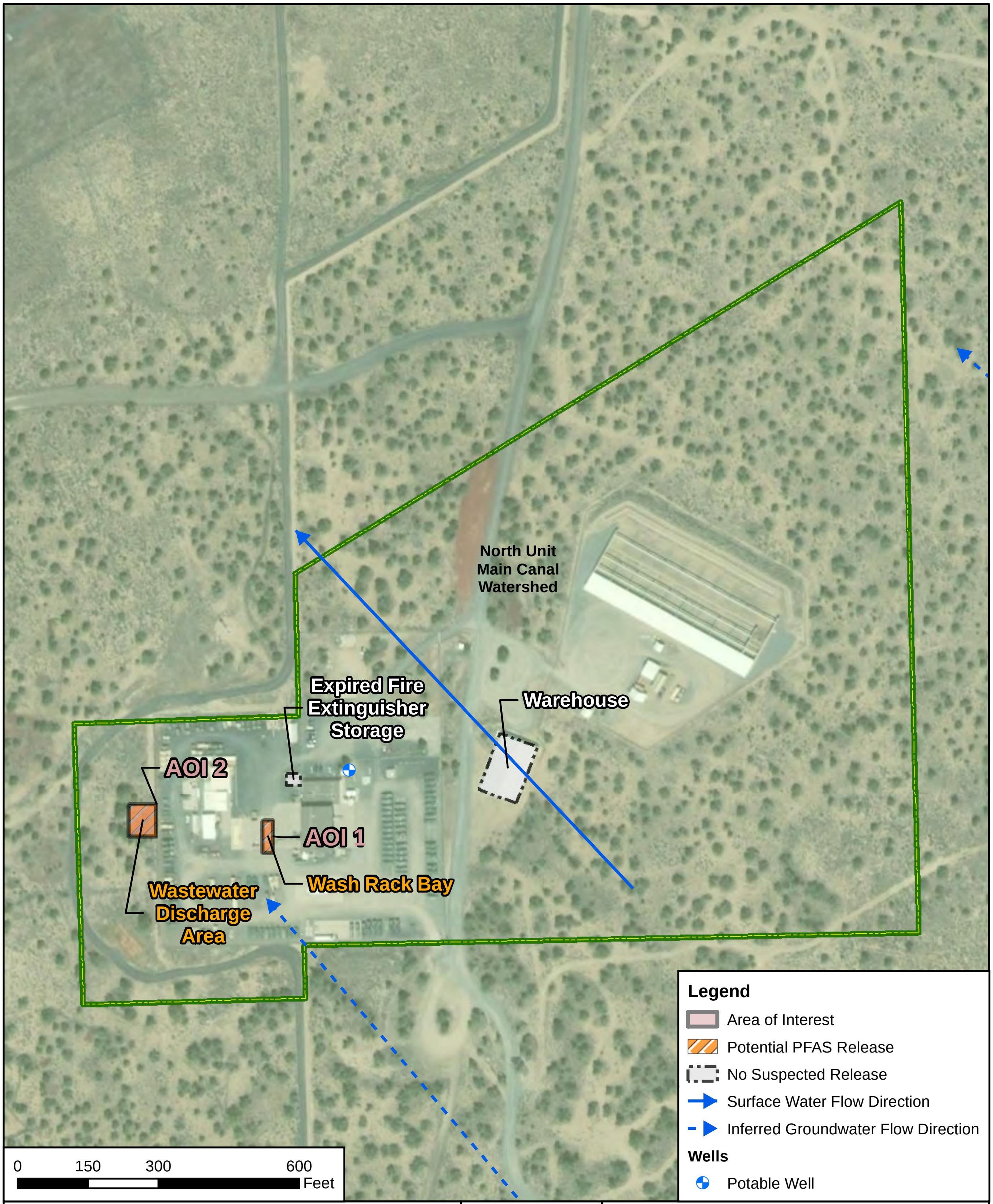
Ground-disturbing activities to surface soil at AOI 1 could result in site worker and construction worker exposure to potential PFAS contamination via inhalation of dust particles or ingestion of surface soil. Because potential PFAS releases to surface soil at AOI 1 may have occurred, PFAS may have migrated from the surface soil to the subsurface soil and groundwater via leaching. Ground-disturbing activities to subsurface soil could result in construction worker exposure via inhalation of soil particles and ingestion of subsurface soil. Therefore, the exposure pathways for ingestion of soil are potentially complete for these receptors. The CSM for AOI 1 is shown on **Figure 6-2**. Based on the static water levels, construction workers at the facility are unlikely to encounter shallow groundwater even under trenching scenarios (typically up to 15 feet below ground surface); therefore, the shallow groundwater ingestion pathway is incomplete for construction workers.

6.2 AOI 2: Wastewater Discharge Area

AOI 2 is at the wastewater discharge area associated with the wash rack bay, which is located west of the facility's operational area, along the western side of the facility fencing. There are no known or documented releases of PFAS at AOI 2. This discharge area is unpaved with a natural vegetative cover. Wastewater from the wash rack bay, which consists of wash water and cleaning detergents is discharged via irrigation, which is permitted under a Water Pollution Control Facility NPDES permit since 2001 (type GEN17B, Water Quality File No. 111416) (DEQ, 2019).

Groundwater flow typically follows the natural topographical gradient. Around AOI 2, subsurface flow is generally to the northwest. One onsite drinking water well is approximately 400 feet to the northeast and cross-gradient of AOI 2. Public drinking water supplies of the Redmond Water Department are found immediately to the west, southwest, and north of the COUTES, generally downgradient of AOI 2 (DEQ, 2018a). Therefore, the exposure pathway for groundwater via ingestion is potentially complete for off-facility residents.

Ground-disturbing activities to surface soil at AOI 2 could result in site worker and construction worker exposure to potential PFAS contamination via inhalation of dust particles or ingestion of surface soil. Because potential PFAS releases to surface soil at AOI 2 may have occurred, PFAS may have migrated from the surface soil to the subsurface soil and groundwater via leaching. Ground-disturbing activities to subsurface soil could result in construction worker exposure via inhalation of soil particles and ingestion of subsurface soil. Therefore, the exposure pathways for ingestion of soil are potentially complete for these receptors. The CSM for AOI 2 is shown on **Figure 6-2**. Based on the static water levels, construction workers at the facility are unlikely to encounter shallow groundwater even under trenching scenarios (typically up to 15 feet below ground surface); therefore, the shallow groundwater ingestion pathway is incomplete for construction workers.



CLIENT	ARNG			
NOTES	Preliminary Assessment for PFAS at Biak COUTES, OR			
REVISED	6/5/2020	GIS BY	MS	6/5/2020
SCALE	1:3,600	CHK BY	MB	6/5/2020
Base Map: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS,		PM	RG	6/5/2020

Areas of Interest

12420 Milestone Center Drive
Germantown, MD 20876

Figure 6-1

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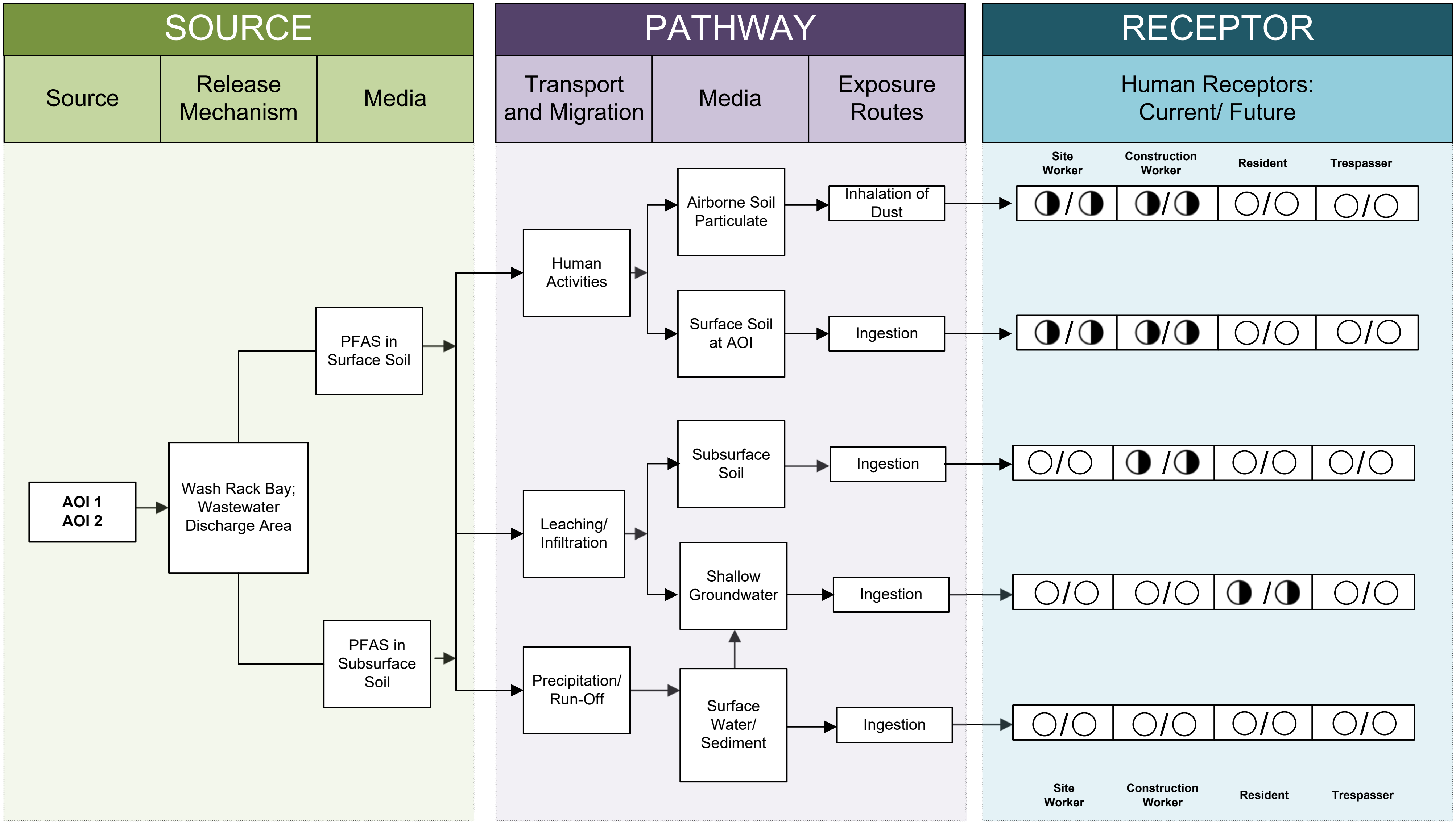


LEGEND

─□ Flow-Chart Stops
──▶ Flow-Chart Continues
– – – ▶ Partial / Possible Flow
○ Incomplete Pathway
◐ Potentially Complete Pathway
● Complete Pathway

Figure 6-2
Preliminary Conceptual Site Model
AOI 1 Wash Rack Bay and AOI 2 Wastewater Discharge Area

7. Conclusions

This report presents a summary of available information gathered during the PA on the use and storage of AFFF and other PFAS-related activities at the COUTES. The PA findings are based on the information presented in **Appendix A** and **Appendix B**.

7.1 Findings

The two AOIs related to potential PFAS release were identified at the COUTES (**Table 7-1**) during the PA through interviews with facility personnel (**Figure 7-1**).

Table 7-1: AOIs at the COUTES

Area of Interest	Name	Used by	Potential Release Dates
AOI 1	Wash Rack Bay	OMD	Unknown
AOI 2	Wastewater Discharge Area	OMD	Unknown

Based on potential PFAS releases at the AOIs, there is potential for exposure to PFAS contamination in media at or near the facility. The preliminary CSM for the AOIs is shown on **Figure 6-2**.

7.2 Uncertainty

A number of information sources were investigated during this PA to determine the potential for PFAS-containing materials to have been stored, used, or released at the facility. Historically, documentation of PFAS use was not required because PFAS were considered benign. Therefore, records were not typically kept by the facility or available during the PA on the disposition and use of PFAS in training, firefighting, or other non-traditional activities.

The conclusions of this PA are based on all available information, including: previous environmental reports, EDR™, observations made during the VSI, and interviews. Interviews of personnel with direct knowledge of a facility generally provided the most useful insights regarding a facility's historical and current PFAS-containing materials. Sometimes, the provided information was vague or conflicted with other sources. Gathered information has a degree of uncertainty due to the absence of written documentation, the limited number of personnel with direct knowledge due to staffing changes, the time passed since PFAS were first used (1987 to present), and a reliance on personal recollection. Inaccuracies may arise in potential PFAS release locations, dates of release, volume of releases, and the concentration of AFFF used. There is also a possibility the PA has missed a source of PFAS, as the science of how PFAS may enter the environment continually evolves.

To minimize the level of uncertainty, readily available data regarding the use and storage of PFAS were reviewed, retired and current personnel were interviewed, multiple persons were interviewed for the same potential source area, and potential source areas were visually inspected. **Table 7-2** summarizes the uncertainties associated with the PA.

Table 7-2: Summary of Uncertainties

Area of Interest	Source of Uncertainty
AOI 1 and AOI 2	Direct interviewee knowledge is not available before 2004. Whether potential use, storage, or release of PFAS-containing materials occurred at this facility prior to 2004 is unknown.

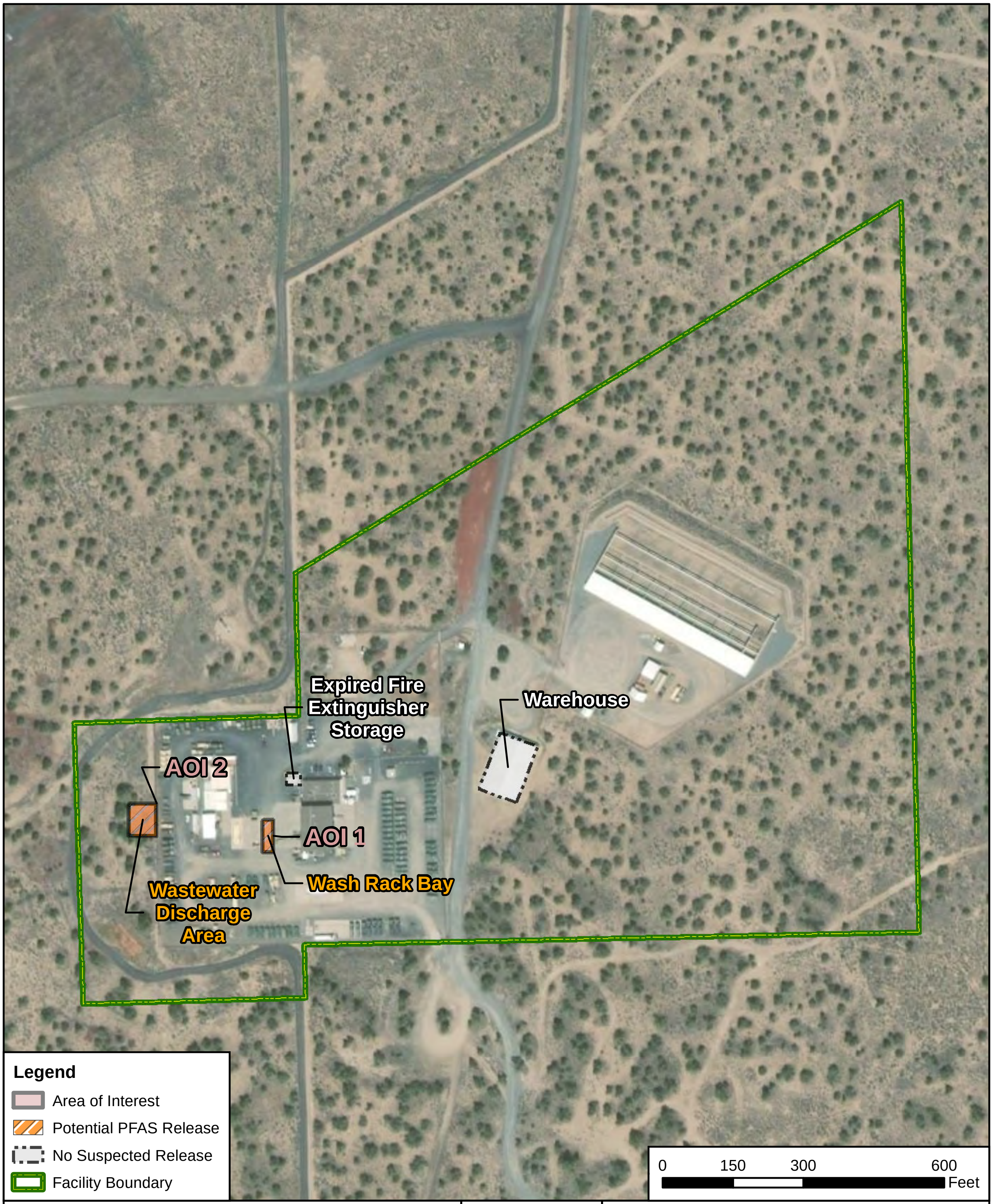
7.3 Potential Future Actions

Interviews and records (covering 2004 to present) indicate that current or former ARNG activities may have resulted in potential PFAS releases at the two AOIs identified during the PA. Based on the CSM developed for the AOIs, there is potential for receptors to be exposed to PFAS contamination in soil and groundwater at these AOIs. **Table 7-3** summarizes the rationale used to determine if the AOIs should be considered for further investigation under the CERCLA process and undergo SI.

ARNG will evaluate the need for an SI based on the potential receptors, the potential migration of PFAS contamination off the facility, and the availability of resources.

Table 7-3 PA Findings Summary

Area of Interest	Rationale	Potential Future Action
AOI 1: Wash Rack Bay	The OMD washes facility equipment and vehicles, which includes fire trucks. According to facility personnel, the fire trucks are only washed during the summer and have not historically, and do not currently, contain AFFF. No information was available on how long the wash rack bay has been used or whether AFFF was contained in the fire trucks prior to 2004.	Proceed to an SI, focus on soil and groundwater
AOI 2: Wastewater Discharge Area	The OMD discharges wastewater from the wash rack bay into a pervious area via irrigation. No information was available on how long the area has been used for wastewater discharge or whether AFFF was contained in the fire trucks prior to 2004.	Proceed to an SI, focus on soil and groundwater



CLIENT	ARNG			
NOTES	Preliminary Assessment for PFAS at Biak COUTES, OR			
REVISED	6/5/2020	GIS BY	MS	6/5/2020
SCALE	1:3,600	CHK BY	MB	6/5/2020
Base Map: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS,		PM	RG	6/5/2020

N

Summary of Findings

AECOM
12420 Milestone Center Drive
Germantown, MD 20876

Figure 7-1

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Appendix A
Data Resources

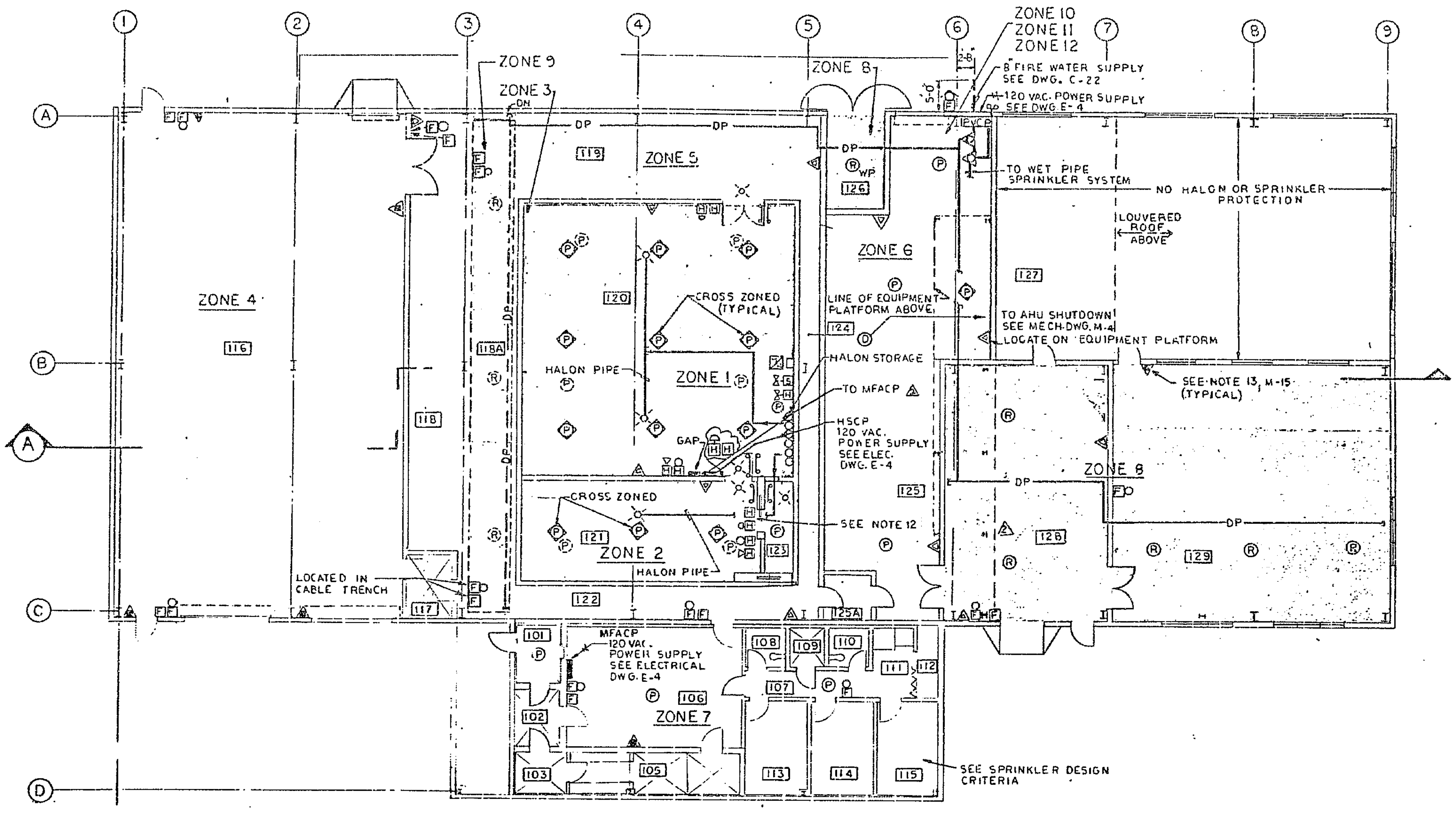
Data Resources will be provided separately on CD. Data Resources for COUTES include:

COUTES Installation Maps

- 2018 Facility Map – Site #41902 Biak Training Center COUTES
- 2018 Facility Map – COUTES Site 41902
- 2018 Area Map – Site #41902 Biak Training Center
- 2016 Area Map – Site #41902 Biak TC RPI
- 1984 Facility Drawing – Fire Protection, Halon, Sprinkler Diagram

COUTES EDR^{TM} Report

- 2018 COUTES Environmental Data Resource Report^{TM}



FIRE PROTECTION PLAN
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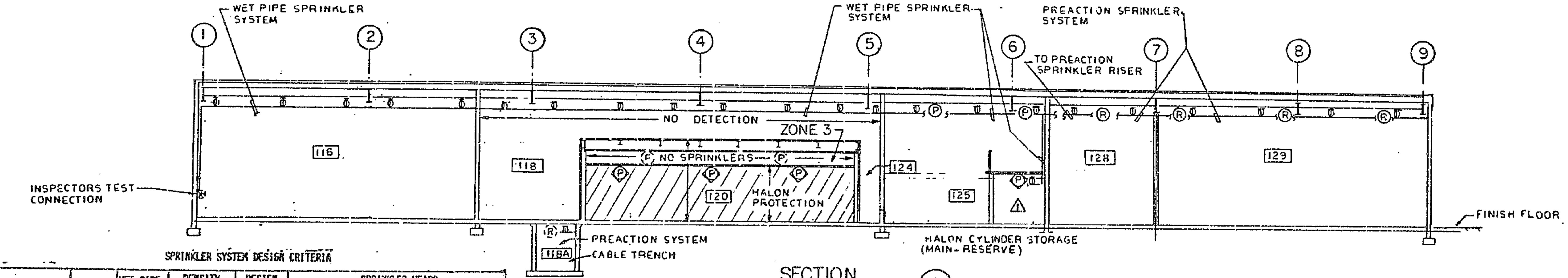


SECTION (A)
SCALE: 1/8"=1'-0"

SPRINKLER SYSTEM DESIGN CRITERIA

ROOM OR AREA	HAZARD CLASS.	WET PIPE OR PREACTION	DENSITY (GPM PER SQ FT)	DESIGN AREA (SQ FT)	SPRINKLER HEADS SPACING (SQ FT)	SPRINKLER HEADS TEMP (oF)	SPRINKLER HEADS POSITION	SPRINKLER HEADS KIND
ROOM 126, 128, 129, CABLE TRENCH-118A	ORDINARY GROUP 1	PREACTION	0.16	1950	130	212	UPRIGHT	BRASS
ROOMS 101 THRU 115	LIGHT	WET	0.10	1500	200	165	PENDENT	CHROME
ROOM 120, 121 (INCLUDING ABOVE AND BELOW SUSPENDED CEILING)	NO	AUTOMATIC	SPRINKLER	PROTECTION				
ALL OTHER AREAS, INCLUDING BELOW EQPT. PLATFORM	ORDINARY	WET	0.16	1500	130	165	*UPRIGHT	*BRASS

*ROOMS WITH SUSPENDED CEILINGS SHALL HAVE PENDENT, CHROME HEADS.

HALON SYSTEM OPERATIONS

THERE ARE TWO SEPARATE HALON PROTECTED AREAS (ZONES 1 AND 2) INSIDE THE SHIELDED ROOM. EACH ZONE IS INDEPENDENT OF THE OTHERS BUT IS SUPPLIED BY A COMMON BANK OF HALON CYLINDERS. THESE CYLINDERS HAVE SELECTOR VALVES TO DETERMINE WHICH CYLINDERS ARE ACTIVATED AND WHICH ZONE IS FLOODED WITH HALON. THERE IS ALSO A RESERVE BANK OF CYLINDERS TO ACT AS A BACK-UP SUPPLY IN CASE THE MAIN BANK HAS BEEN EXPENDED

ACTUATION OF A PHOTOELECTRIC DETECTOR IN EITHER DETECTION CIRCUIT (CROSS-ZONED) OF A HALON ZONE SHALL:

1. LIGHT THE ZONE LAMP ON THE HSCP
2. LIGHT THE DETECTOR LOCATION INDICATOR LAMP ON THE GRAPHIC ANNUNCIATOR PANEL (UNDERFLOOR DETECTORS ONLY)
3. SOUND THE ALARM BELLS INSIDE THE ZONE
4. TRANSMIT ALARM SIGNAL TO THE MFACP (RM 106)

ACTUATION OF A PHOTOELECTRIC DETECTOR ON BOTH DETECTION CIRCUITS OF A HALON ZONE SHALL: (IN ADDITION TO THE OPERATIONS STATED ABOVE)

1. SOUND THE HALON DISCHARGE HORN (HORN TONE SHALL BE "BEEP" TYPE
2. ACTUATE FLASHING LIGHTS OUTSIDE THE ROOM TO INDICATE HALON DISCHARGE
3. TRANSMIT THIS NEW ALARM SIGNAL TO THE MFACP
4. SHUT OFF THE AIR CONDITIONING SYSTEM INSIDE THE ZONE
5. SHUT OFF AIR HANDLING UNITS LOCATED OUTSIDE THE ZONE BUT SERVING THE ZONE
6. CLOSE THE MOTORIZED DAMPERS SERVING THE ZONE
7. ACTUATE THE TIMER FOR THE HALON DISCHARGE
8. DISCHARGE HALON INTO THE AFFECTED ZONE FOLLOWING THE PRE-DISCHARGE TIME DELAY PERIOD OF 30 - 60 SECONDS

ACTUATION OF A MANUAL PULL HALON DISCHARGE STATION SHALL FOLLOW THE SAME OPERATIVE PROCEDURES AS FOR THE CROSS-ZONED DETECTOR ACTIVATION SITUATION ⚠

REFERENCE DRAWINGS

NO.	DATE	ISSUE/REV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0	11/12/84	FOR CONST	PV	[illegible]	[illegible]			
1	1-24-85	FOR CONST	PV	RP				
2	2-15-85	REV. AS NOTED	PV	RP	[illegible]		[illegible]	
3	12-6-85	AS BUILT	MM				[illegible]	

NOTES:

1. FOR LEGENDS AND ABBREVIATIONS SEE M-15.
2. THE LOCATION OF THE DETECTORS SHOWN ARE ONLY APPROXIMATE AND MUST BE LOCATED BY CONTRACTOR TO CONFORM WITH INSTALLATION REQUIREMENTS OF NFPA 72E AND MANUFACTURERS RECOMMENDATION. PLACEMENT OF DETECTORS MUST CONSIDER LOCATION OF AIR SUPPLY DIFFUSERS, AIR RETURN OPENINGS, LIGHT FIXTURES, STRUCTURAL MEMBERS AND ANYTHING ELSE THAT MAY INTERFERE WITH PROPER OPERATION OF THE DETECTOR.
3. THE STYLE B WIRING FOR DETECTORS IS NOT SHOWN BUT REQUIRES TWO #14 AWG FROM EACH DEVICE TO EACH DEVICE.
4. DETECTOR COVERAGE SHALL BE SUCH THAT SPACING WILL NOT EXCEED THE FOLLOWING:
   A. ABOVE SUSPENDED CEILING=500 SQ. FT.;
   B. ON CEILING=500 SQ. FT.;
   C. ON CEILING (HALON PROTECTED AREAS)=250 SQ. FT.;
   D. BELOW FLOOR=250 SQ. FT.
5. ALL HIDDEN DETECTORS ABOVE SUSPENDED CEILING SHALL BE DEPICTED ON A GRAPHIC ANNUNCIATOR PANEL (GAP).
6. OPERATION AND RELEASE OF HALON IS PREDICATED ON AUTOMATIC DETECTION OF SMOKE BY CROSS ZONED DETECTORS. FOR A COMPLETE DESCRIPTION OF THE HALON SYSTEM OPERATION SEE SPECIFICATIONS.
7. ALL HALON PROTECTED AREAS SHALL BE PROVIDED WITH A 6% CONCENTRATION OF HALON 1301 FOR A MINIMUM HOLDING TIME OF 10 MINUTES AND DISCHARGE RELEASE NOT TO EXCEED 10 SECONDS. HALON CYLINDER VALVES SHALL BE ELECTRO-PNEUMATIC AND RELEASE THE HALON 1301 THROUGH AN ENGINEERED PIPED MANIFOLD SO THAT EITHER THE MAIN OR RESERVE BANK OF HALON CYLINDERS CAN ADEQUATELY PROTECT ANY OF THE TWO HALON ZONES THROUGH THE USE OF SELECTOR VALVES
8. LOCATION AND SPACING OF HALON NOZZLES AND PIPING ARE ONLY APPROXIMATE AND MUST BE LOCATED BY CONTRACTOR TO CONFORM WITH DESIGN REQUIREMENTS AND WITH NFPA 12A. SHOP DRAWINGS MUST BE SUBMITTED ACCORDING TO THE SPECIFICATIONS. ACTUAL LAYOUT OF THE HALON SYSTEM MUST CONSIDER LOCATION OF DUCTS, STRUCTURAL MEMBERS, UNDERFLOOR WALLS AND ANYTHING ELSE THAT MAY INTERFERE WITH PROPER OPERATION OF THE SYSTEM.

CONTINUED ON NEXT SHEET

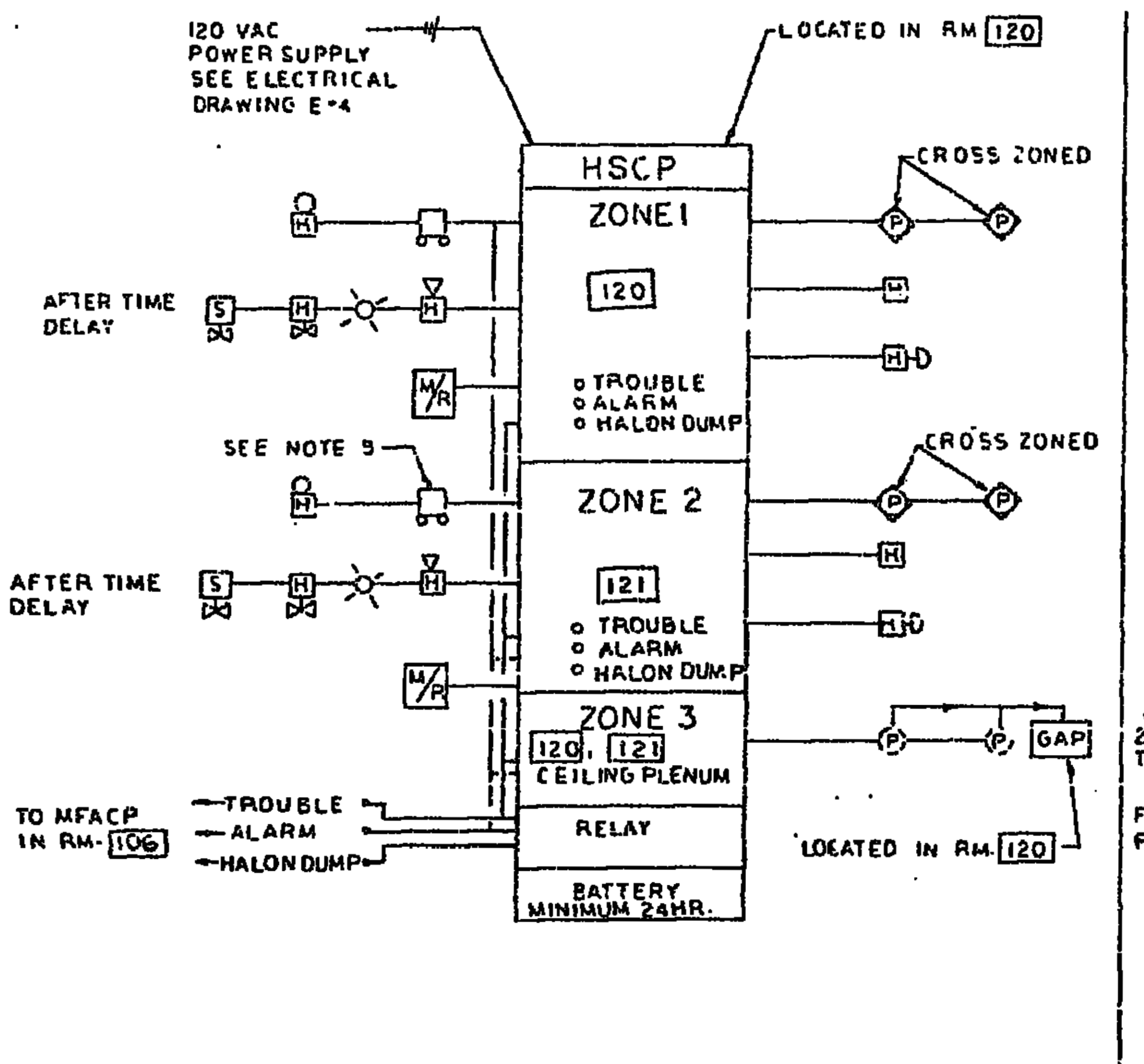
NORTH ARROW

GRAPHIC SCALES:
1/8"=1'
5 0 5 10 15 20
scale feet

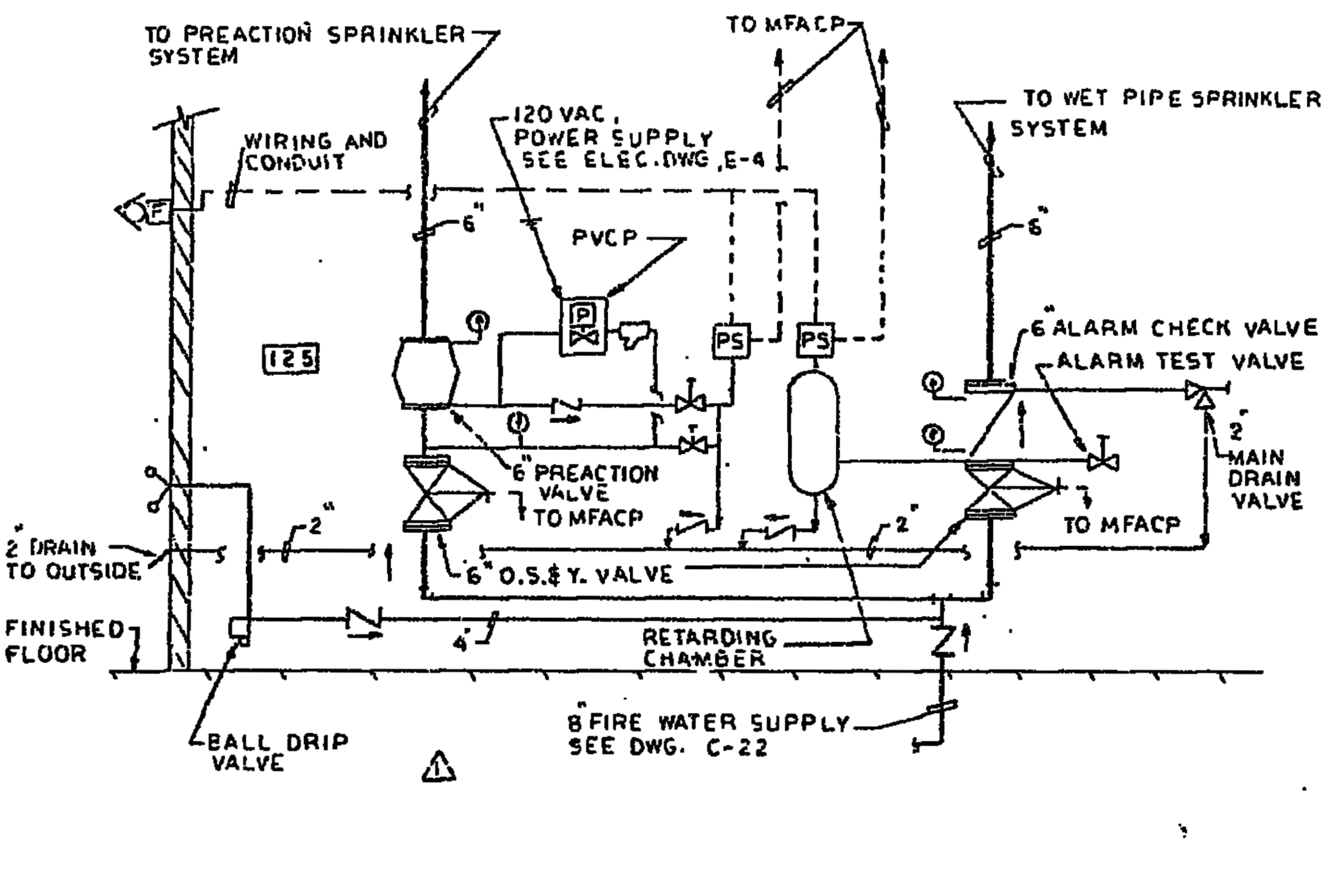
TITLE:
TEST BUILDING
FIRE PROTECTION,
HALON,
SPRINKLER DIAGRAMS

HOLMES & NARVER, INC.
ARCHITECTS-ENGINEERS
ORANGE, CALIFORNIA

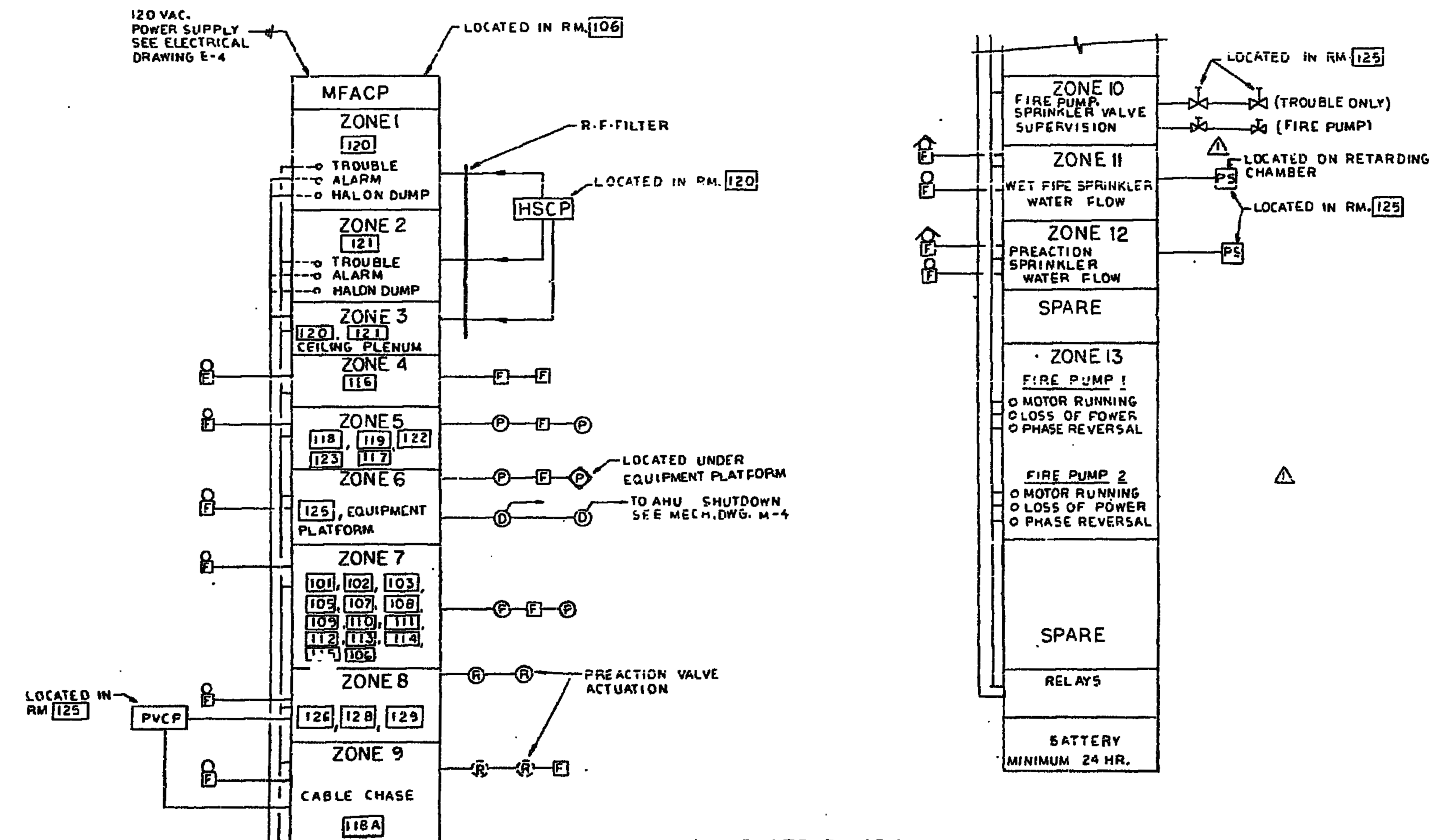
IGS NO.
JOB NO. 1652.21
DATE: 11-12-84
DRAWING NO. M-14
REVISION 3



HALON SYSTEM RISER DIAGRAM
N.T.S.



AUTOMATIC SPRINKLER RISER SYSTEM SCHEMATIC
N.T.S.



FIRE ALARM RISER DIAGRAM
N.T.S

LEGEND

H◁	ALARM HORN
MFACP	MASTER FIRE ALARM CONTROL PANEL
HSCP	HALON SYSTEM CONTROL PANEL
P	PHOTOELECTRIC DETECTOR (HALON RM, EQPT. PLATFORM)
H	HALON DISCHARGE STATION
H D	HALON ABORT STATION
☼	FLASHING RED LIGHT, HALON DISCHARGE
H O	ALARM BELL HALON PRE-DISCHARGE
	HALON 1301 WARNING SIGN
H	HALON SOLENOID VALVE
S	HALON SELECTOR VALVE
	MOTORIZED DAMPER
R	HEAT DETECTOR, RATE OF RISE
R WP	HEAT DETECTOR, WEATHER PROOF, RATE OF RISE
F	MANUAL FIRE ALARM STATION
F O	ALARM BELL
PS	PRESSURE SWITCH
P	SOLENOID VALVE, PREACTION VALVE
D	DUCT DETECTOR
PVCP	PREACTION VALVE CONTROL PANEL
	PRESSURE GAGE
	CHECK VALVE
	OUTSIDE SCREW AND YOKE VALVE (SUPERVIZED)
	GATE VALVE
R	HEAT DETECTOR, RATE OF RISE, CABLE CHASE
F	ALARM BELL, 8", WEATHER PROOF
▲	HALON 1211 PORTABLE EXTINGUISHER, 13LBS, UL.RATED, 2A:40B:C
▲	DRY CHEMICAL PORTABLE EXTINGUISHER, 10LBS, UL. RATED, 4A:60B:C, (MULTIPURPOSE)
	STRAINER
	AUTOMATIC SPRINKLER HEAD, UPRIGHT
	AUTOMATIC SPRINKLER HEAD, PENDENT
P	PHOTOELECTRIC DETECTOR, HIDDEN
GAP	GRAPHIC ANNUNCIATOR PANEL
M/R	MAIN-RESERVE TRANSFER SWITCH
	FIRE DEPARTMENT CONNECTION
☼	HALON 1301 DISCHARGE NOZZLE
△	WET PIPE SPRINKLER RISER
▲	PREACTION SPRINKLER RISER
P	PHOTOELECTRIC DETECTOR
-F-	FIRE PROTECTION WATER MAIN
	FIRE HYDRANT

ABBREVIATION

DEPT.	DEPARTMENT
DP	DRY PIPE, SHADED PORTION SHOWS AREAS PROTECTED
VAC.	VOLTS ALTERNATING CURRENT
ELEC.	ELECTRICAL
MECH.	MECHANICAL
DN	DOWN
N.T.S.	NOT TO SCALE
R.F.	RADIO FREQUENCY
RM.	ROOM
EQPT.	EQUIPMENT
AHU	AIR HANDLING UNIT
SQ.FT.	SQUARE FEET
GPM.	GALLONS PER MINUTE
DWG.	DRAWING
U.L.	UNDERWRITERS LABORATORIES INC.
NFPA	NATIONAL FIRE PROTECTION ASSOCIATION
N.I.C.	NOT IN CONTRACT
CONT.	CONTINUATION
AWG.	AMERICAN WIRE GAUGE

REFERENCE DRAWINGS

NO.	DATE	ISSUE/REV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0	11/12/84	FOR CONST	PV					
1	1-24-85	FOR CONST	PV					
2	11-4-86	AS BUILT	NM					

NOTES:

9. SEE MECHANICAL DRAWINGS FOR VENTILATION ARRANGEMENTS OF HALON PROTECTED ROOMS AND LOCATION OF MOTORIZED DAMPERS FOR CONTAINING HALON INSIDE OF PROTECTED ROOMS. SEE ELECTRICAL DRAWING FOR WIRING/CONDUIT AND SHUTDOWN OPERATIONS.

10. LOCATION AND SPACING OF SPRINKLER HEADS AND PIPING ARE NOT SHOWN BUT MUST BE LOCATED BY CONTRACTOR TO CONFORM WITH DESIGN REQUIREMENTS AND WITH NFPA 13. SHOP DRAWINGS MUST BE SUBMITTED ACCORDING TO THE SPECIFICATIONS. ACTUAL LAYOUT OF SPRINKLER SYSTEM MUST CONSIDER LOCATION OF DUCTS, STRUCTURAL MEMBERS AND ANYTHING ELSE THAT MAY INTERFERE WITH PROPER OPERATION OF THE SYSTEM.
11. THERE IS NO AUTOMATIC SPRINKLER PROTECTION IN HALON PROTECTED AREAS AND AREAS ABOVE THE HALON PROTECTED ROOM SUSPENDED CEILING SINCE NO COMBUSTIBLE MATERIALS ARE PRESENT.
12. ALL RF SHIELD PENETRATIONS BY SPRINKLER PIPING AND HALON PIPING SHALL CONFORM WITH THE SPECIFICATIONS. SEE ARCHITECTURAL DRAWINGS FOR RF SHIELD LOCATION & DETAIL 2, M-6 FOR A PIPE PENETRATING THE SHIELD.

13. ALL FIRE EXTINGUISHERS SHALL BE WALL MOUNTED (NO FIRE EXTINGUISHER CABINETS). THE KIND AND RATING OF THE FIRE EXTINGUISHERS ARE SHOWN FOR INFORMATION ONLY. THE EXTINGUISHERS SHALL BE PROVIDED BY OWNER (NIC).

NOV. 10, 1987

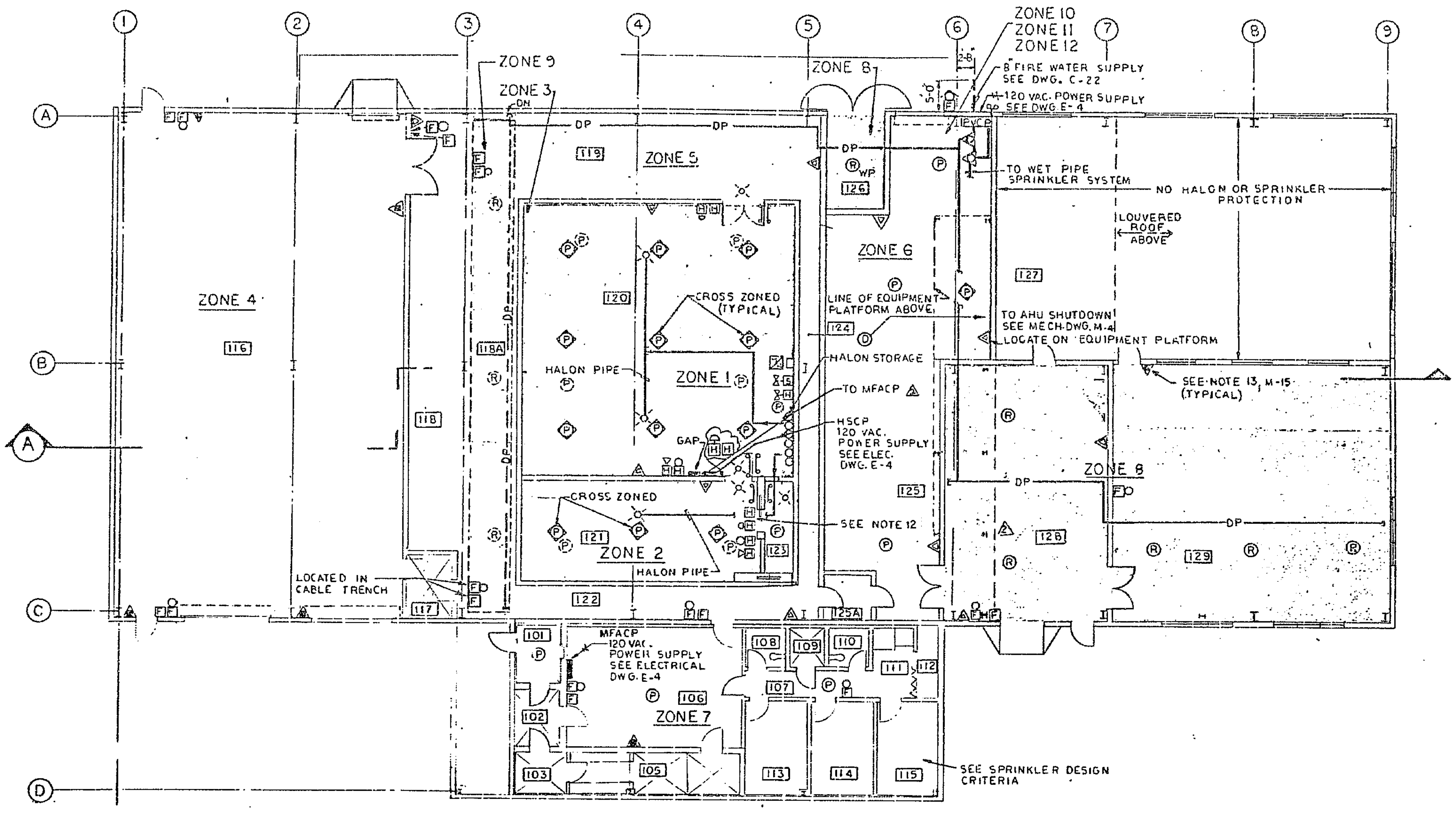
NORTH ARROW
NONE

GRAPHIC SCALES:
NONE

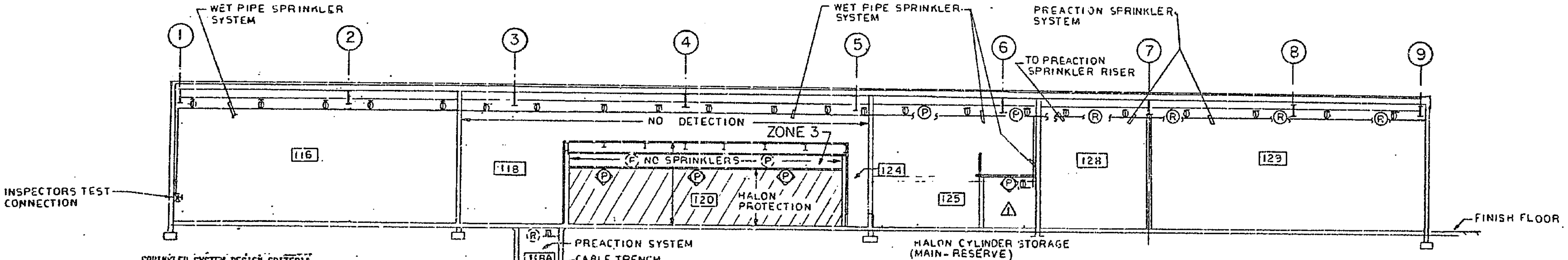
TITLE:
TEST BUILDING
FIRE PROTECTION,
RISER DIAGRAMS,
CONTROL DESCRIPTIONS

HOLMES & NARVER, INC.
ARCHITECTS-ENGINEERS
ORANGE, CALIFORNIA

IGS NO.
JOB NO. 1652.21
DATE 11-12-84
DRAWING NO. M-15
REVISION 2



FIRE PROTECTION PLAN
SCALE: 1/8"=1'-0"



SECTION (A)
SCALE: 1/8"=1'-0"

SPRINKLER SYSTEM DESIGN CRITERIA

ROOM OR AREA	HAZARD CLASS.	WET PIPE OR PREACTION	DENSITY (GPM PER SQ FT)	DESIGN AREA (SQ FT)	SPRINKLER HEADS			
					SPACING (SQ FT)	TEMP (°F)	POSITION	KIND
ROOM 126, 128, 129, CABLE TRENCH-118A	ORDINARY GROUP 1	PREACTION	0.16	1950	130	212	UPRIGHT	BRASS
ROOMS 101 THRU 115	LIGHT	WET	0.10	1500	200	165	PENDENT	CHROME
ROOM 120, 121 (INCLUDING ABOVE AND BELOW SUSPENDED CEILING)	NO	AUTOMATIC	SPRINKLER	PROTECTION				
ALL OTHER AREAS, INCLUDING BELOW EQPT. PLATFORM	ORDINARY	WET	0.16	1500	130	165	*UPRIGHT	*BRASS

*ROOMS WITH SUSPENDED CEILINGS SHALL HAVE PENDENT, CHROME HEADS.

HALON SYSTEM OPERATIONS

THERE ARE TWO SEPARATE HALON PROTECTED AREAS (ZONES 1 AND 2) INSIDE THE SHIELDED ROOM. EACH ZONE IS INDEPENDENT OF THE OTHERS BUT IS SUPPLIED BY A COMMON BANK OF HALON CYLINDERS. THESE CYLINDERS HAVE SELECTOR VALVES TO DETERMINE WHICH CYLINDERS ARE ACTIVATED AND WHICH ZONE IS FLOODED WITH HALON. THERE IS ALSO A RESERVE BANK OF CYLINDERS TO ACT AS A BACK-UP SUPPLY IN CASE THE MAIN BANK HAS BEEN EXPENDED

ACTUATION OF A PHOTOELECTRIC DETECTOR IN EITHER DETECTION CIRCUIT (CROSS-ZONED) OF A HALON ZONE SHALL:

1. LIGHT THE ZONE LAMP ON THE HSCP
2. LIGHT THE DETECTOR LOCATION INDICATOR LAMP ON THE GRAPHIC ANNUNCIATOR PANEL (UNDERFLOOR DETECTORS ONLY)
3. SOUND THE ALARM BELLS INSIDE THE ZONE
4. TRANSMIT ALARM SIGNAL TO THE MFACP (RM 106)

ACTUATION OF A PHOTOELECTRIC DETECTOR ON BOTH DETECTION CIRCUITS OF A HALON ZONE SHALL:
(IN ADDITION TO THE OPERATIONS STATED ABOVE)

1. SOUND THE HALON DISCHARGE HORN (HORN TONE SHALL BE "BEEP" TYPE
2. ACTUATE FLASHING LIGHTS OUTSIDE THE ROOM TO INDICATE HALON DISCHARGE
3. TRANSMIT THIS NEW ALARM SIGNAL TO THE MFACP
4. SHUT OFF THE AIR CONDITIONING SYSTEM INSIDE THE ZONE
5. SHUT OFF AIR HANDLING UNITS LOCATED OUTSIDE THE ZONE BUT SERVING THE ZONE
6. CLOSE THE MOTORIZED DAMPERS SERVING THE ZONE
7. ACTUATE THE TIMER FOR THE HALON DISCHARGE
8. DISCHARGE HALON INTO THE AFFECTED ZONE FOLLOWING THE PRE-DISCHARGE TIME DELAY PERIOD OF 30 - 60 SECONDS

ACTUATION OF A MANUAL PULL HALON DISCHARGE STATION SHALL FOLLOW THE SAME OPERATIVE PROCEDURES AS FOR THE CROSS-ZONED DETECTOR ACTIVATION SITUATION

△2

REFERENCE DRAWINGS

NO.	DATE	ISSUE/REV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CLIENT
0	11/12/84	FOR CONST	PV	[illegible]	[illegible]			
△1	1-24-85	FOR CONST	PV	RP				
△2	2-15-85	REV. AS NOTED	PV	RP	[illegible]		[illegible]	
△3	12-6-85	AS BUILT	[illegible]				[illegible]	

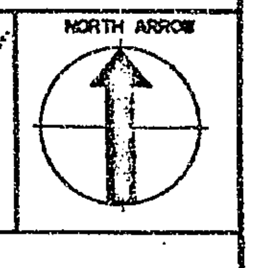
NOTES:

1. FOR LEGENDS AND ABBREVIATIONS SEE M-15.
2. THE LOCATION OF THE DETECTORS SHOWN ARE ONLY APPROXIMATE AND MUST BE LOCATED BY CONTRACTOR TO CONFORM WITH INSTALLATION REQUIREMENTS OF NFPA 72E AND MANUFACTURERS RECOMMENDATION. PLACEMENT OF DETECTORS MUST CONSIDER LOCATION OF AIR SUPPLY DIFFUSERS, AIR RETURN OPENINGS, LIGHT FIXTURES, STRUCTURAL MEMBERS AND ANYTHING ELSE THAT MAY INTERFERE WITH PROPER OPERATION OF THE DETECTOR.
3. THE STYLE B WIRING FOR DETECTORS IS NOT SHOWN BUT REQUIRES TWO #14 AWG FROM EACH DEVICE TO EACH DEVICE.
4. DETECTOR COVERAGE SHALL BE SUCH THAT SPACING WILL NOT EXCEED THE FOLLOWING:
   - A. ABOVE SUSPENDED CEILING=500 SQ. FT.;
   - B. ON CEILING=500 SQ. FT.;
   - C. ON CEILING (HALON PROTECTED AREAS)= 250 SQ. FT.;
   - D. BELOW FLOOR=250 SQ. FT.
5. ALL HIDDEN DETECTORS ABOVE SUSPENDED CEILING SHALL BE DEPICTED ON A GRAPHIC ANNUNCIATOR PANEL (GAP).
6. OPERATION AND RELEASE OF HALON IS PREDICATED ON AUTOMATIC DETECTION OF SMOKE BY CROSS ZONED DETECTORS. FOR A COMPLETE DESCRIPTION OF THE HALON SYSTEM OPERATION SEE SPECIFICATIONS.
7. ALL HALON PROTECTED AREAS SHALL BE PROVIDED WITH A 6% CONCENTRATION OF HALON 1301 FOR A MINIMUM HOLDING TIME OF 10 MINUTES AND DISCHARGE RELEASE NOT TO EXCEED 10 SECONDS. HALON CYLINDER VALVES SHALL BE ELECTRO-PNEUMATIC AND RELEASE THE HALON 1301 THROUGH AN ENGINEERED PIPED MANIFOLD SO THAT EITHER THE MAIN OR RESERVE BANK OF HALON CYLINDERS CAN ADEQUATELY PROTECT ANY OF THE TWO HALON ZONES THROUGH THE USE OF SELECTOR VALVES
8. LOCATION AND SPACING OF HALON NOZZLES AND PIPING ARE ONLY APPROXIMATE AND MUST BE LOCATED BY CONTRACTOR TO CONFORM WITH DESIGN REQUIREMENTS AND WITH NFPA 12A. SHOP DRAWINGS MUST BE SUBMITTED ACCORDING TO THE SPECIFICATIONS. ACTUAL LAYOUT OF THE HALON SYSTEM MUST CONSIDER LOCATION OF DUCTS, STRUCTURAL MEMBERS, UNDERFLOOR WALLS AND ANYTHING ELSE THAT MAY INTERFERE WITH PROPER OPERATION OF THE SYSTEM.

CONTINUED ON NEXT SHEET

REGISTERED PROFESSIONAL ENGINEER
R. R. Ahn

NORTH ARROW

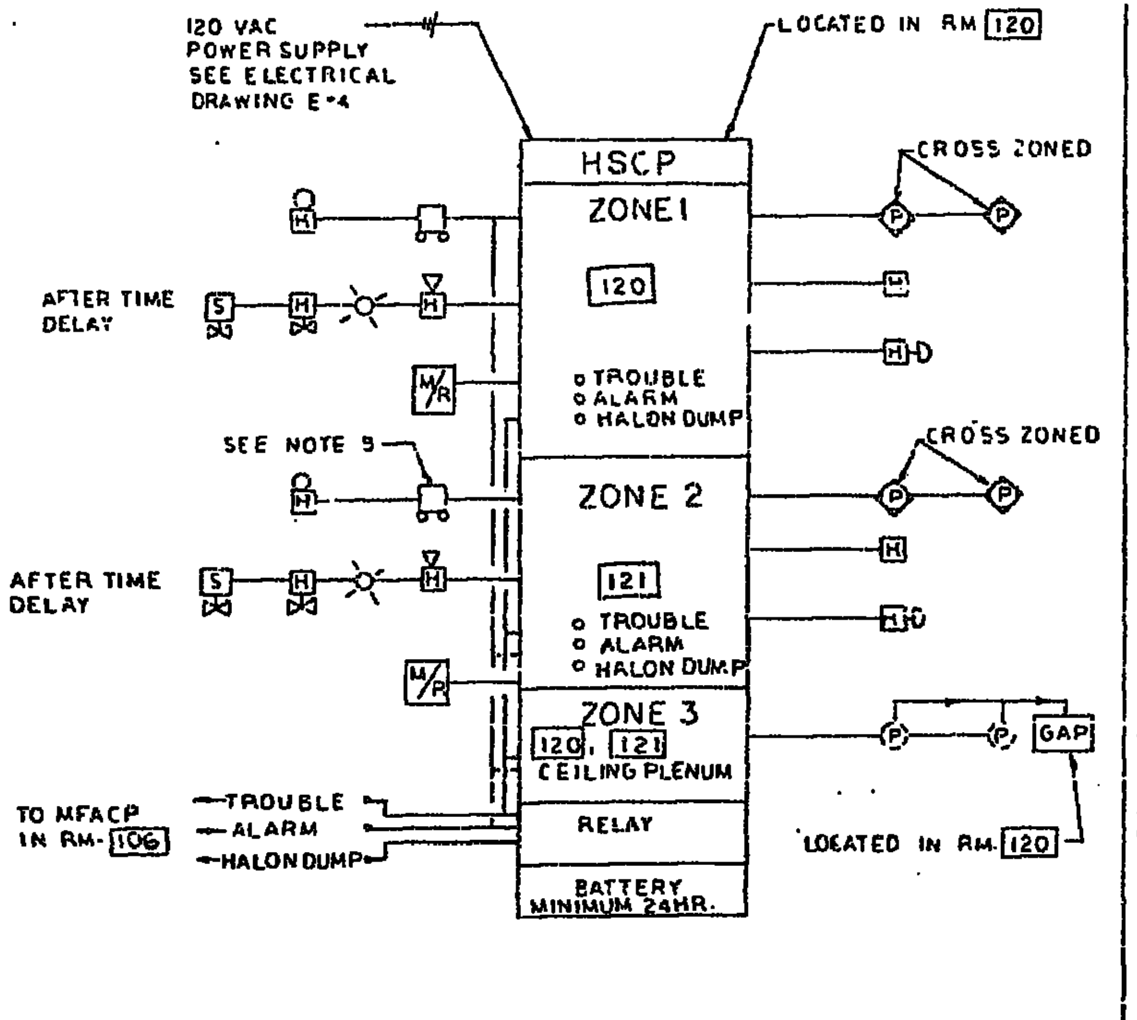


GRAPHIC SCALES:
1/8"=1'
5 0 5 10 15 20
scale feet

TITLE:
TEST BUILDING
FIRE PROTECTION,
HALON,
SPRINKLER DIAGRAMS

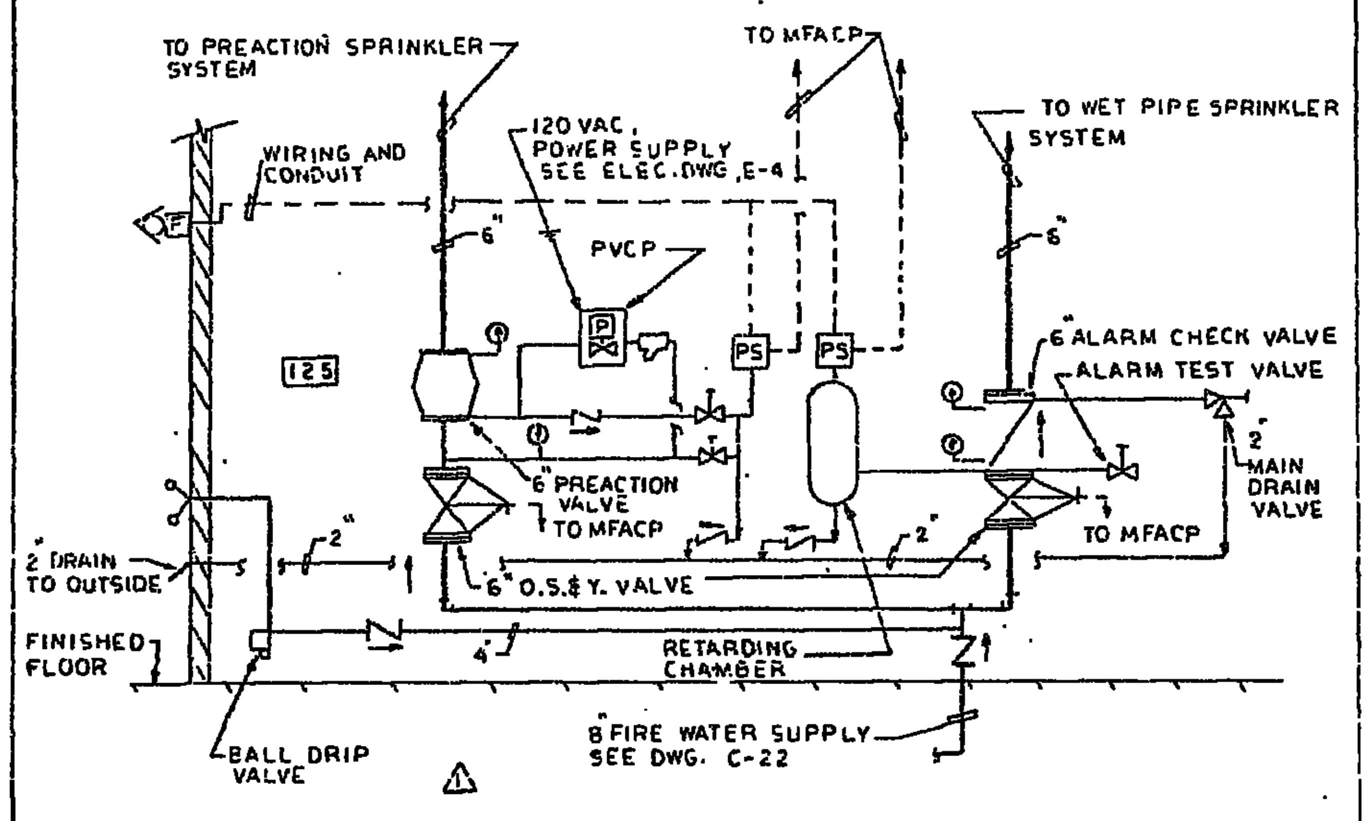
HOLMES & NARVER, INC.
ARCHITECTS-ENGINEERS
ORANGE, CALIFORNIA

IGS NO.
DATE: 11-12-84
JOB NO. 1652.21
DRAWING NO. M-14
REVISION 3



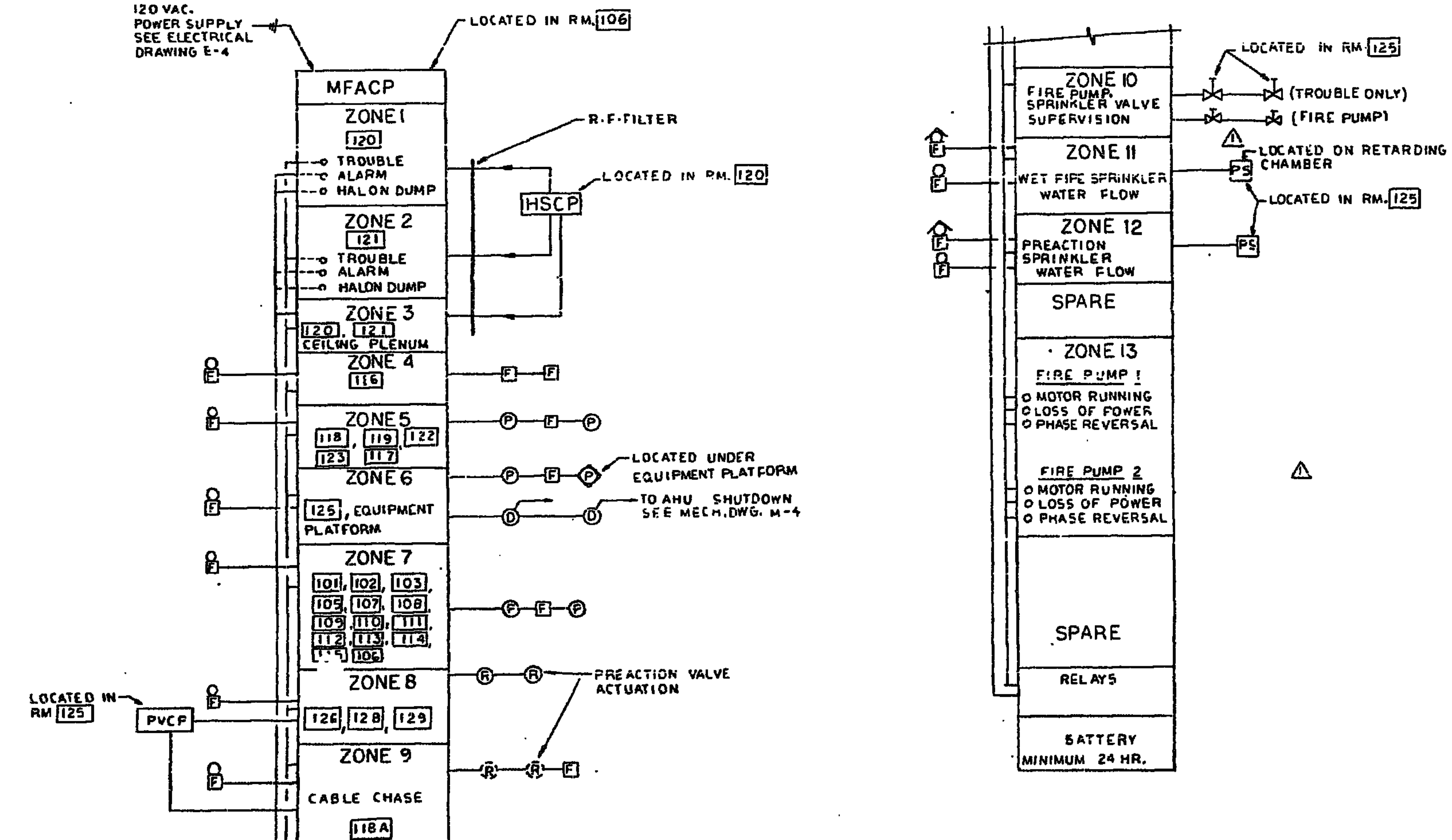
HALON SYSTEM RISER DIAGRAM

N.T.S.



AUTOMATIC SPRINKLER RISER SYSTEM SCHEMATIC

N.T.S.



FIRE ALARM RISER DIAGRAM

N.T.S

LEGEND

H◁	ALARM HORN
MFACP	MASTER FIRE ALARM CONTROL PANEL
HSCP	HALON SYSTEM CONTROL PANEL
◇P	PHOTOELECTRIC DETECTOR (HALON RM, EQPT. PLATFORM)
H	HALON DISCHARGE STATION
HD	HALON ABORT STATION
☼	FLASHING RED LIGHT, HALON DISCHARGE
HO	ALARM BELL HALON PRE-DISCHARGE
⌴	HALON 1301 WARNING SIGN
H ⋈	HALON SOLENOID VALVE
S ⋈	HALON SELECTOR VALVE
☐	MOTORIZED DAMPER
Ⓡ	HEAT DETECTOR, RATE OF RISE
ⓇWP	HEAT DETECTOR, WEATHER PROOF, RATE OF RISE
F	MANUAL FIRE ALARM STATION
FO	ALARM BELL
PS	PRESSURE SWITCH
P ⋈	SOLENOID VALVE, PREACTION VALVE
Ⓓ	DUCT DETECTOR
PVCP	PREACTION VALVE CONTROL PANEL
ⓟ	PRESSURE GAGE
⋈	CHECK VALVE
⋈	OUTSIDE SCREW AND YOKE VALVE (SUPERVIZED)
⋈	GATE VALVE
(R)	HEAT DETECTOR, RATE OF RISE, CABLE CHASE
⌂ F	ALARM BELL, 8", WEATHER PROOF
△	HALON 1211 PORTABLE EXTINGUISHER, 13LBS, UL.RATED, 2A:40B:C
▲	DRY CHEMICAL PORTABLE EXTINGUISHER, 10LBS, UL. RATED, 4A:60B:C, (MULTIPURPOSE)
⊤	STRAINER
⊤	AUTOMATIC SPRINKLER HEAD, UPRIGHT
⊥	AUTOMATIC SPRINKLER HEAD, PENDENT
(P)	PHOTOELECTRIC DETECTOR, HIDDEN
GAP	GRAPHIC ANNUNCIATOR PANEL
M/R	MAIN-RESERVE TRANSFER SWITCH
⊸	FIRE DEPARTMENT CONNECTION
☼	HALON 1301 DISCHARGE NOZZLE
△	WET PIPE SPRINKLER RISER
▲	PREACTION SPRINKLER RISER
Ⓟ	PHOTOELECTRIC DETECTOR
-F-	FIRE PROTECTION WATER MAIN
⍝	FIRE HYDRANT

ABBREVIATION

DEPT.	DEPARTMENT
DP	DRY PIPE, SHADED PORTION SHOWS AREAS PROTECTED
VAC.	VOLTS ALTERNATING CURRENT
ELEC.	ELECTRICAL
MECH.	MECHANICAL
DN	DOWN
N.T.S.	NOT TO SCALE
R.F.	RADIO FREQUENCY
RM.	ROOM
EQPT.	EQUIPMENT
AHU	AIR HANDLING UNIT
SQ.FT.	SQUARE FEET
GPM.	GALLONS PER MINUTE
DWG.	DRAWING
U.L.	UNDERWRITERS LABORATORIES INC.
NFPA	NATIONAL FIRE PROTECTION ASSOCIATION
N.I.C.	NOT IN CONTRACT
CONT.	CONTINUATION
AWG.	AMERICAN WIRE GAUGE

REFERENCE DRAWINGS

NO.	DATE	ISSUE/REV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0	11-12-84	FOR CONST	PV					
1	1-24-85	FOR CONST	PV					
2	11-26-85	AS BUILT	NM					

NOTES:

9. SEE MECHANICAL DRAWINGS FOR VENTILATION ARRANGEMENTS OF HALON PROTECTED ROOMS AND LOCATION OF MOTORIZED DAMPERS FOR CONTAINING HALON INSIDE OF PROTECTED ROOMS. SEE ELECTRICAL DRAWING FOR WIRING/CONDUIT AND SHUTDOWN OPERATIONS.

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R. R. AWY
NOV. 10, 1983

NORTH ARROW
NONE

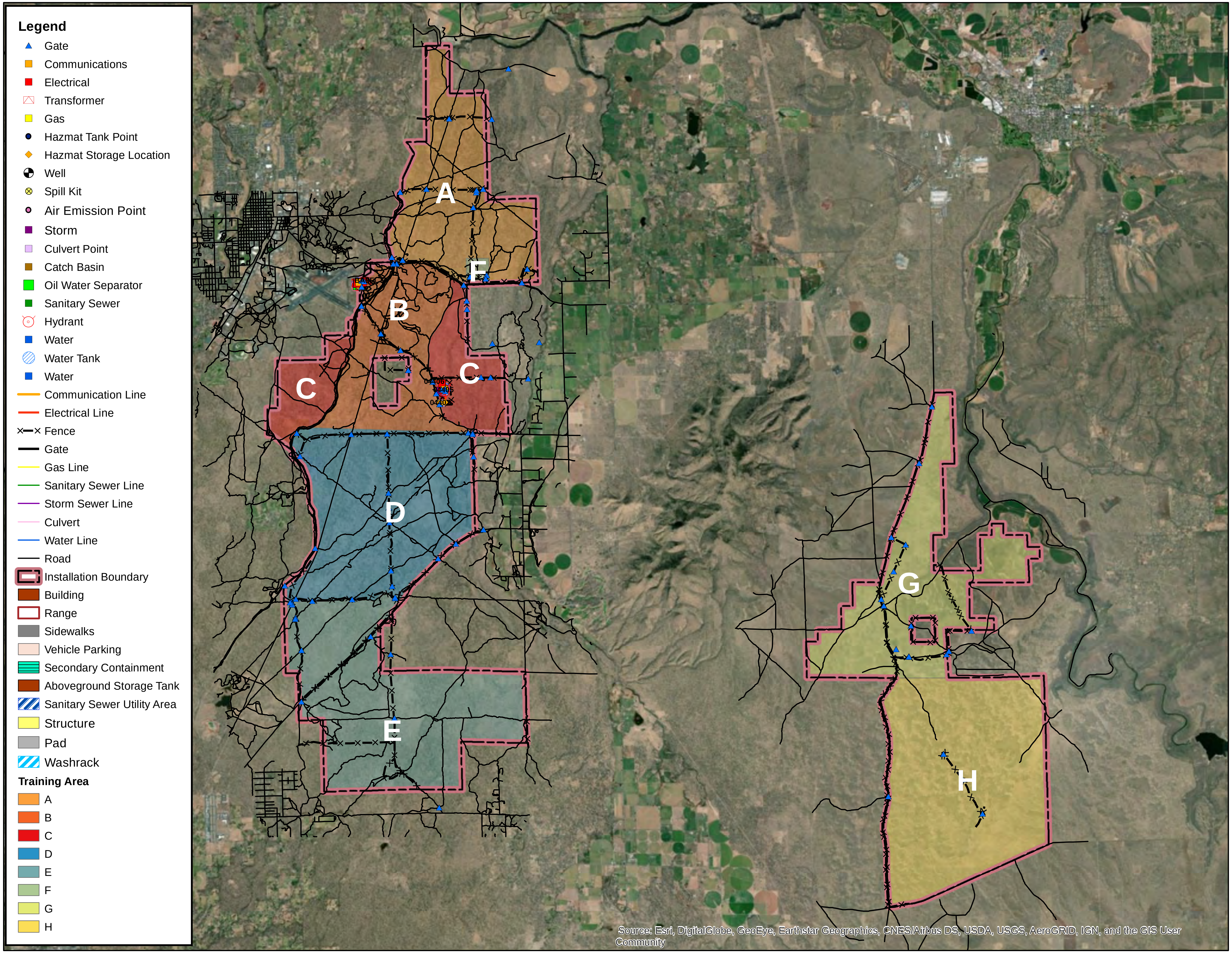
GRAPHIC SCALES:
NONE

TITLE:
TEST BUILDING
FIRE PROTECTION,
RISER DIAGRAMS,
CONTROL DESCRIPTIONS

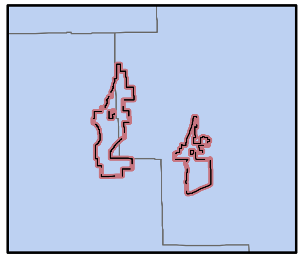
HOLMES & NARVER, INC.
ARCHITECTS-ENGINEERS
ORANGE, CALIFORNIA

IGS NO.
DATE: 11-12-84
JOB NO. 1652.21
DRAWING NO. M-15
REVISION 2

Site # 41902
Biak
Training Center



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



1 inch = 9,886 feet

0 5,000 10,000 20,000 Feet

T: 15 S R: 15 E Sec: 02
NAD 83 UTM Zone 10 North
Projection: Transverse Mercator
Aug 2018

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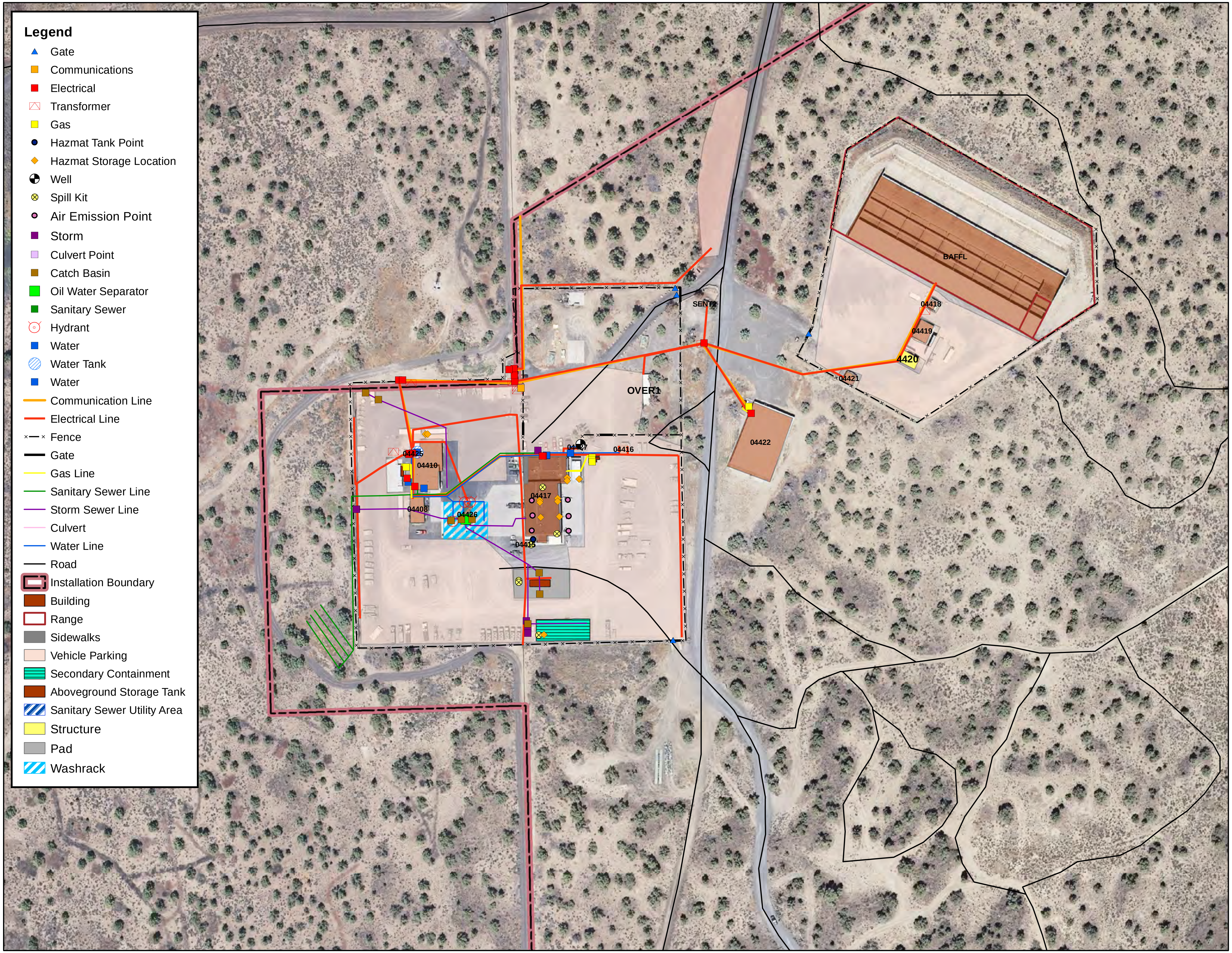
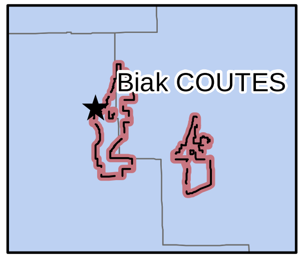


Site # 41902
Biak
Training Center
COUTES



1 inch = 167 feet
0 50 100 200
Feet

T: 15 S R: 15 E Sec: 02
NAD 83 UTM Zone 10 North
Projection: Transverse Mercator
Aug 2018

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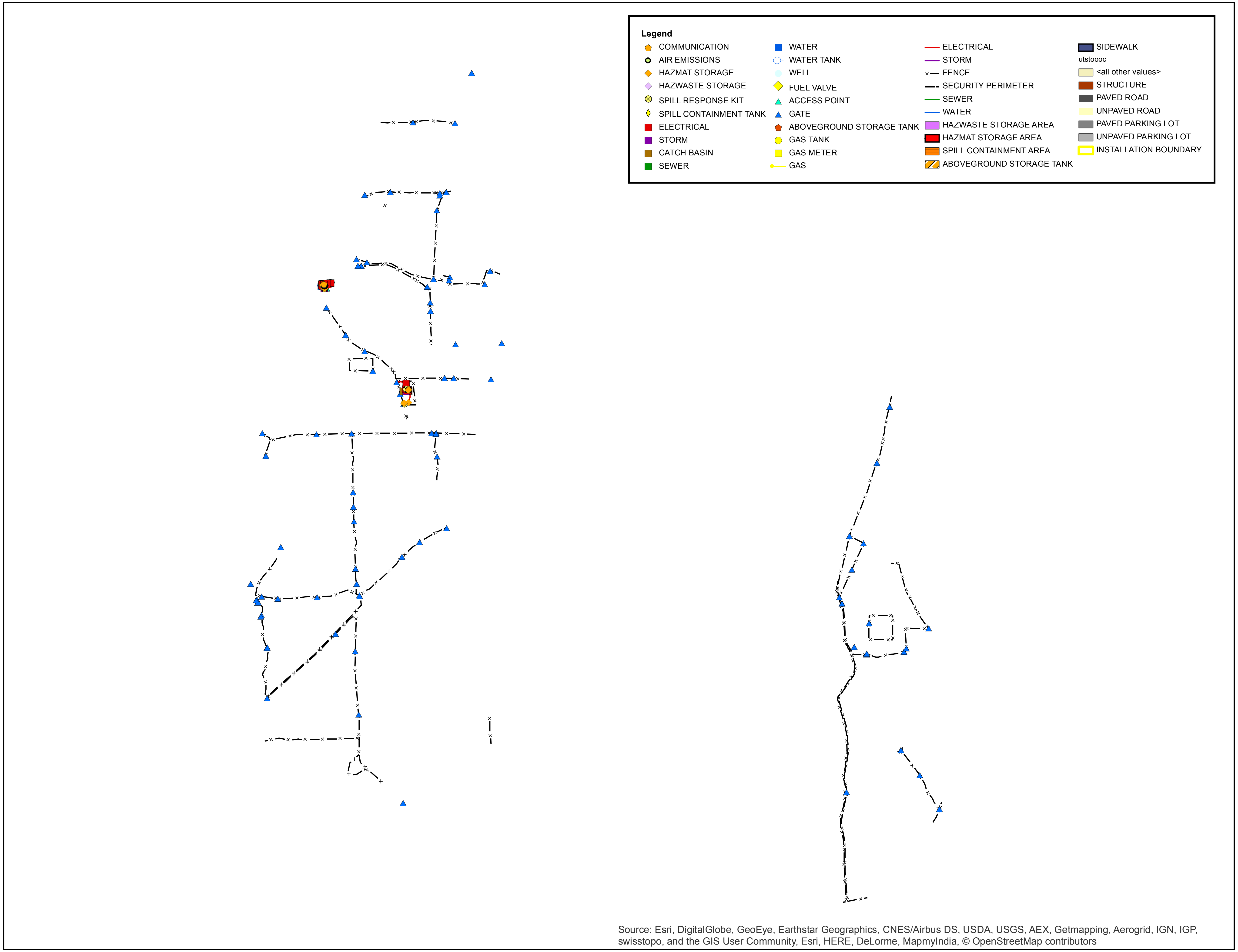
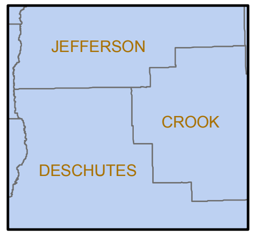
Site # 41902
BIAK TC
RPI



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors



Address:
2899 E 126 Hwy
Redmond, OR
97756

1 inch = 10,000 feet

0 5,000 10,000 20,000

Feet

T15S R13E Sec. 23, GIS Acreage = 41.97
NAD 83 HARN State Plane OR S
Projection: Lambert Conformal Conic
2016 AGI KH

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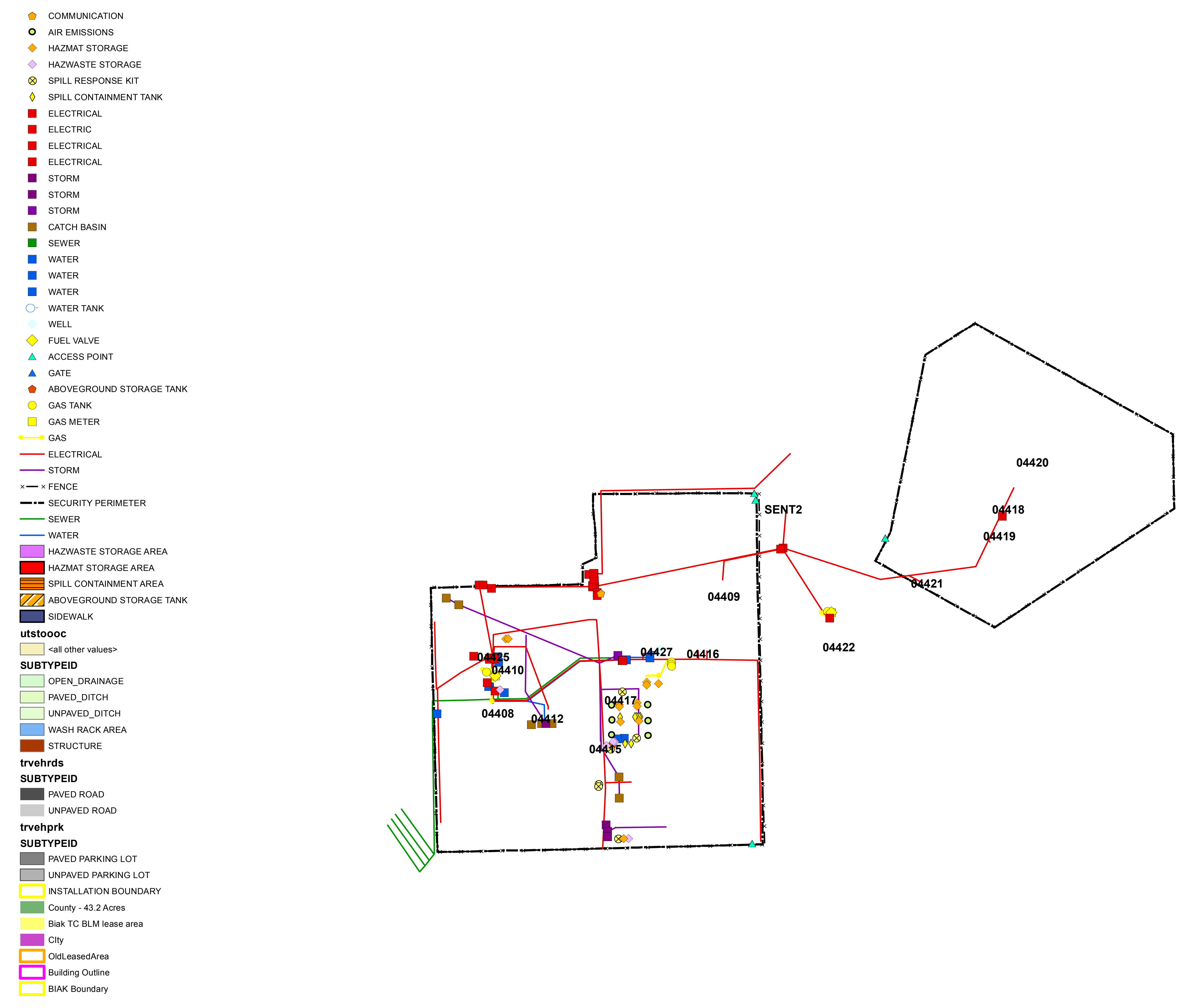

COUTES
Site: 41902

N
W E
S

0 50100 200 300 400
Feet
1 inch = 200 feet

NAD 83 UTM Zone 10N
Projection: Transverse Mercator
2016 AGI KH

Imagery Source:
County Imagery through ESRI
Produced by USDA

The information on this map is for internal Guard planning purposes only. This map is a "Living document," in that it is intended to change as new data becomes available and is incorporated into the Enterprise GIS database

Fax To: AECOM
Contact: Brittany Kirchmann
Fax : 000-000-0000
Date: 10/25/2018

Fax From: Sean McLaughlin
EDR
Phone: 1-800-352-0050

EDR PUR-IQ® Report

"the intelligent way to conduct historical research"

for
Redmond BIAK COUTES
2522 SE Jesse Butler Cir
Redmond, OR 97756
Lat./Long. 44.255065 / 121.131854
EDR Inquiry # 5464928.2s

The EDR PUR-IQ report facilitates historical research planning required to complete the Phase I ESA process. The report identifies the *likelihood* of prior use coverage by searching proprietary EDR-Prior Use Reports® comprising nationwide information on: city directories, fire insurance maps, aerial photographs, historical topographic maps, flood maps and National Wetland Inventory maps.

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1. Building Permits:	Building Permits are available for 'REDMOND', OR (1973 - 2017).
2. City Directory:	Coverage may exist for portions of Deschutes County, OR.
3. Fire Insurance Map:	When you order online any EDR Package or the EDR Radius Map with EDR Sanborn Map Search/Print, you receive site specific Sanborn Map coverage information at no charge.
4. Aerial Photograph:	Aerial photography coverage may exist for portions of Deschutes County. Please contact your EDR Account Executive for information about USGS photos available through EDR.
5. Topographic Map:	The USGS 7.5 min. quad topo sheet(s) associated with this site:

Historical: Coverage exists for DESCHUTES County

Current:	Target Property:	TP | 2014 | 6067500 Redmond, OR
	Additional required for 1 Mile radius:	NE | 2014 | 6067530 O'Neil, OR SE | 2014 | 6067496 Powell Butte, OR SW | 2014 | 6067448 Forked Horn Butte, OR

EDR's network of professional researchers, located throughout the United States, accesses the most extensive national collections of city directory, fire insurance maps, aerial photographs and historical topographic map resources available for Redmond, OR. These collections may be located in multiple libraries throughout the country. To ensure maximum coverage, EDR will often assign researchers at these multiple locations on your behalf. Please call or fax your EDR representative to authorize a search.

EDR™ Environmental Data Resources Inc

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AECOM
Brittany Kirchmann
Account # 1861179

Redmond BIAK COUTES
2522 SE Jesse Butler Cir
Redmond, OR 97756
DESCHUTES County
Lat./Long. 44.255065 / 121.131854
EDR Inquiry # 5464928.2s

Should you wish to change or add to your order, fax this form to your EDR account executive:

Sean McLaughlin
Ph: 1-800-352-0050 Fax: 1-800-231-6802

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___ EDR City Directory Abstract

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Redmond BIAK COUTES
2522 SE Jesse Butler Cir
Redmond, OR 97756

Inquiry Number: 5464928.3
October 25, 2018

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Certified Sanborn® Map Report

10/25/18

Site Name:

Redmond BIAK COUTES
2522 SE Jesse Butler Cir
Redmond, OR 97756
EDR Inquiry # 5464928.3

Client Name:

AECOM
12120 Shamrock Plaza
Omaha, NE 68154
Contact: Brittany Kirchmann

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PO # NA

Project Redmond BIAK COUTES

UNMAPPED PROPERTY

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Sanborn® Library search results

Certification #: 36D4-4448-987D

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- ☑ University Publications of America
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Redmond BIAK COUTES
2522 SE Jesse Butler Cir
Redmond, OR 97756

Inquiry Number: 5464928.5
October 26, 2018

The EDR Aerial Photo Decade Package

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EDR Aerial Photo Decade Package

10/26/18

Site Name:

Redmond BIAK COUTES
2522 SE Jesse Butler Cir
Redmond, OR 97756
EDR Inquiry # 5464928.5

Client Name:

AECOM
12120 Shamrock Plaza
Omaha, NE 68154
Contact: Brittany Kirchmann

Environmental Data Resources, Inc. (EDR) Aerial Photo Decade Package is a screening tool designed to assist environmental professionals in evaluating potential liability on a target property resulting from past activities. EDR's professional researchers provide digitally reproduced historical aerial photographs, and when available, provide one photo per decade.

Search Results:

Year	Scale	Details	Source
2016	1"=500'	Flight Year: 2016	USDA/NAIP
2012	1"=500'	Flight Year: 2012	USDA/NAIP
2009	1"=500'	Flight Year: 2009	USDA/NAIP
2006	1"=500'	Flight Year: 2006	USDA/NAIP
1994	1"=500'	Acquisition Date: May 08, 1994	USGS/DOQQ
1982	1"=500'	Flight Date: July 29, 1982	USDA
1980	1"=500'	Flight Date: August 02, 1980	USGS
1953	1"=500'	Flight Date: September 17, 1953	USGS
1951	1"=500'	Flight Date: July 28, 1951	USDA
1938	1"=500'	Flight Date: June 05, 1938	USDA

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INQUIRY #: 5464928.5

YEAR: 2016

= 500'

INQUIRY #: 5464928.5

YEAR: 2012

= 500'

INQUIRY #: 5464928.5

YEAR: 2009

= 500'

INQUIRY #: 5464928.5

YEAR: 2006

= 500'

N

INQUIRY #: 5464928.5

YEAR: 1994

= 500'

N

Subject boundary not shown because it exceeds image extent or image is not georeferenced.

INQUIRY #: 5464928.5

YEAR: 1982

= 500'

INQUIRY #: 5464928.5

YEAR: 1980

= 500'

N

INQUIRY #: 5464928.5

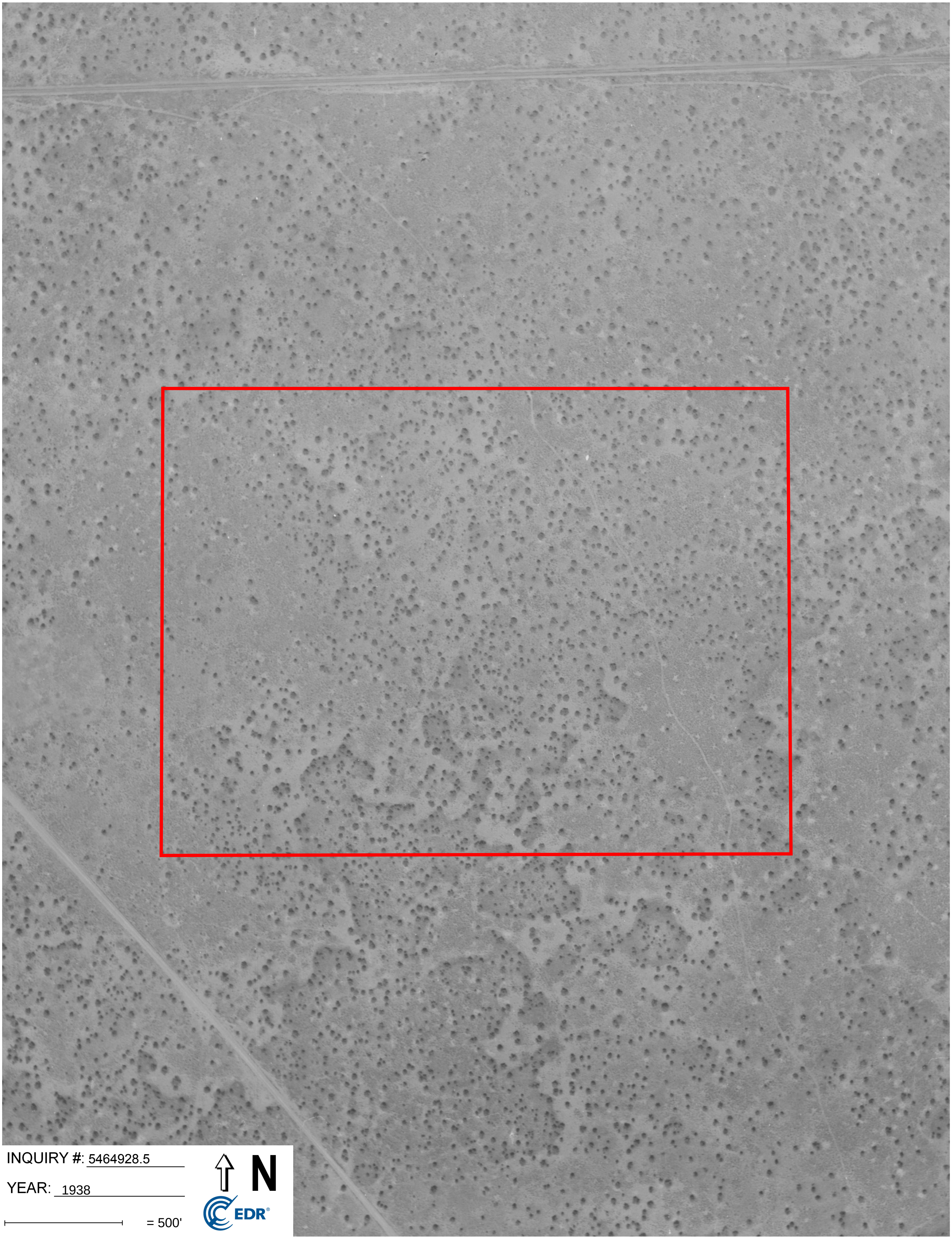
YEAR: 1953

= 500'

INQUIRY #: 5464928.5

YEAR: 1951

= 500'



INQUIRY #: 5464928.5

YEAR: 1938

= 500'

Redmond BIAK COUTES
2522 SE Jesse Butler Cir
Redmond, OR 97756

Inquiry Number: 5464928.2s
October 25, 2018

The EDR Radius Map™ Report with GeoCheck®

EDR®

6 Armstrong Road, 4th floor
Shelton, CT 06484
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GEOCHECK ADDENDUM

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EXECUTIVE SUMMARY

A search of available environmental records was conducted by Environmental Data Resources, Inc (EDR). The report was designed to assist parties seeking to meet the search requirements of EPA's Standards and Practices for All Appropriate Inquiries (40 CFR Part 312), the ASTM Standard Practice for Environmental Site Assessments (E 1527-13), the ASTM Standard Practice for Environmental Site Assessments for Forestland or Rural Property (E 2247-16), the ASTM Standard Practice for Limited Environmental Due Diligence: Transaction Screen Process (E 1528-14) or custom requirements developed for the evaluation of environmental risk associated with a parcel of real estate.

TARGET PROPERTY INFORMATION

ADDRESS

2522 SE JESSE BUTLER CIR
REDMOND, OR 97756

COORDINATES

Latitude (North):	44.2550650 - 44˚ 15' 18.23''
Longitude (West):	121.1318540 - 121˚ 7' 54.67''
Universal Tranverse Mercator:	Zone 10
UTM X (Meters):	649138.9
UTM Y (Meters):	4901683.5
Elevation:	3069 ft. above sea level

USGS TOPOGRAPHIC MAP ASSOCIATED WITH TARGET PROPERTY

Target Property Map:	6067500 REDMOND, OR
Version Date:	2014
Northeast Map:	6067530 O'NEIL, OR
Version Date:	2014
Southeast Map:	6067496 POWELL BUTTE, OR
Version Date:	2014
Southwest Map:	6067448 FORKED HORN BUTTE, OR
Version Date:	2014

AERIAL PHOTOGRAPHY IN THIS REPORT

Portions of Photo from:	20140605
Source:	USDA

MAPPED SITES SUMMARY

Target Property Address:
2522 SE JESSE BUTLER CIR
REDMOND, OR 97756

Click on Map ID to see full detail.

MAP ID	SITE NAME	ADDRESS	DATABASE ACRONYMS	RELATIVE ELEVATION	DIST (ft. & mi.) DIRECTION
A1		2522 SE JESSE BUTLER	OR HAZMAT		TP
A2	ROBERTS FIELD TERMIN	2522 SE JESSE BUTLER	RGA HWS		TP
A3	REDMOND MUNICIPAL AI	2522 SE JESSE BUTLER	ECSI, VCP, UIC		TP
A4	REDMOND CITY OF	2522 SE JESSE BUTLER	AST, HSIS		TP
A5		2522 SE JESSE BUTLER	OR HAZMAT		TP
6	DESCHUTES CO. PROPER	2555 E HWY 126	ECSI, BROWNFIELDS	Lower	3786, 0.717, WNW
7	BIAK TRAINING CENTER		ECSI	Higher	4344, 0.823, East
B8	REDMOND MUNICIPAL AI	1020-1050 SE SISTERS	ECSI, VCP	Lower	4824, 0.914, WNW
B9	REDMOND MUNICIPAL AI	1020 SE SISTERS AVE	ECSI	Lower	4824, 0.914, WNW
10	MAX MILLS FORMERLY O	HWY 126 (BTWN 27TH &	ECSI, VCP	Lower	4847, 0.918, WNW
B11	DESCHUTES READY MIX	700 SW SISTERS AVE	ECSI, VCP, UIC	Lower	4973, 0.942, WNW

EXECUTIVE SUMMARY

TARGET PROPERTY SEARCH RESULTS

The target property was identified in the following records. For more information on this property see page 8 of the attached EDR Radius Map report:

Site	Database(s)	EPA ID
2522 SE JESSE BUTLER 2522 SE JESSE BUTLER REDMOND, OR 97756	OR HAZMAT Facility Id: 1440852	N/A
ROBERTS FIELD TERMIN 2522 SE JESSE BUTLER REDMOND, OR	RGA HWS	N/A
REDMOND MUNICIPAL AI 2522 SE JESSE BUTLER REDMOND, OR 97756	ECSI Investigation: No Further Action State ID Number: 5121 VCP ECS Site ID: 5121 UIC Facility Status: Applied for permit UIC Number: 12415	N/A
REDMOND CITY OF 2522 SE JESSE BUTLER REDMOND, OR 97756	AST Facility Id: 033518 HSIS Facility Id: 033518	N/A
2522 SE JESSE BUTLER 2522 SE JESSE BUTLER REDMOND, OR 97756	OR HAZMAT Facility Id: 1443274	N/A

DATABASES WITH NO MAPPED SITES

No mapped sites were found in EDR’s search of available ("reasonably ascertainable ") government records either on the target property or within the search radius around the target property for the following databases:

STANDARD ENVIRONMENTAL RECORDS

Federal NPL site list

NPL - National Priority List

Proposed NPL	Proposed National Priority List Sites
NPL LIENS	Federal Superfund Liens

Federal Delisted NPL site list

Delisted NPL	National Priority List Deletions

Federal CERCLIS list

FEDERAL FACILITY	Federal Facility Site Information listing
SEMS	Superfund Enterprise Management System

Federal CERCLIS NFRAP site list

SEMS-ARCHIVE	Superfund Enterprise Management System Archive

Federal RCRA CORRACTS facilities list

CORRACTS	Corrective Action Report

Federal RCRA non-CORRACTS TSD facilities list

RCRA-TSDF	RCRA - Treatment, Storage and Disposal

Federal RCRA generators list

RCRA-LQG	RCRA - Large Quantity Generators
RCRA-SQG	RCRA - Small Quantity Generators
RCRA-CESQG	RCRA - Conditionally Exempt Small Quantity Generator

Federal institutional controls / engineering controls registries

LUCIS	Land Use Control Information System
US ENG CONTROLS	Engineering Controls Sites List
US INST CONTROL	Sites with Institutional Controls

Federal ERNS list

ERNS	Emergency Response Notification System

State- and tribal - equivalent CERCLIS

CRL	Confirmed Release List and Inventory

State and tribal landfill and/or solid waste disposal site lists

SWF/LF	Solid Waste Facilities List

State and tribal leaking storage tank lists

LUST	Leaking Underground Storage Tank Database
INDIAN LUST	Leaking Underground Storage Tanks on Indian Land

State and tribal registered storage tank lists

FEMA UST	Underground Storage Tank Listing

EXECUTIVE SUMMARY

UST	Underground Storage Tank Database
INDIAN UST	Underground Storage Tanks on Indian Land

State and tribal institutional control / engineering control registries

ENG CONTROLS	Engineering Controls Recorded at ESCI Sites
INST CONTROL	Institutional Controls Recorded at ESCI Sites

State and tribal voluntary cleanup sites

INDIAN VCP	Voluntary Cleanup Priority Listing

State and tribal Brownfields sites

BROWNFIELDS	Brownfields Projects

ADDITIONAL ENVIRONMENTAL RECORDS

Local Brownfield lists

US BROWNFIELDS	A Listing of Brownfields Sites

Local Lists of Landfill / Solid Waste Disposal Sites

HIST LF	Old Closed SW Disposal Sites
SWRCY	Recycling Facility Location Listing
INDIAN ODI	Report on the Status of Open Dumps on Indian Lands
ODI	Open Dump Inventory
DEBRIS REGION 9	Torres Martinez Reservation Illegal Dump Site Locations
IHS OPEN DUMPS	Open Dumps on Indian Land

Local Lists of Hazardous waste / Contaminated Sites

US HIST CDL	Delisted National Clandestine Laboratory Register
AOCONCERN	Columbia Slough
CDL	Uninhabitable Drug Lab Properties
US CDL	National Clandestine Laboratory Register

Local Land Records

LIENS 2	CERCLA Lien Information

Records of Emergency Release Reports

HMIRS	Hazardous Materials Information Reporting System
SPILLS	Spill Database
SPILLS 90	SPILLS 90 data from FirstSearch

Other Ascertainable Records

RCRA NonGen / NLR	RCRA - Non Generators / No Longer Regulated
FUDS	Formerly Used Defense Sites
DOD	Department of Defense Sites
SCRD DRYCLEANERS	State Coalition for Remediation of Drycleaners Listing

EXECUTIVE SUMMARY

US FIN ASSUR	Financial Assurance Information
EPA WATCH LIST	EPA WATCH LIST
2020 COR ACTION	2020 Corrective Action Program List
TSCA	Toxic Substances Control Act
TRIS	Toxic Chemical Release Inventory System
SSTS	Section 7 Tracking Systems
ROD	Records Of Decision
RMP	Risk Management Plans
RAATS	RCRA Administrative Action Tracking System
PRP	Potentially Responsible Parties
PADS	PCB Activity Database System
ICIS	Integrated Compliance Information System
FTTS	FIFRA/ TSCA Tracking System - FIFRA (Federal Insecticide, Fungicide, & Rodenticide Act)/TSCA (Toxic Substances Control Act)
MLTS	Material Licensing Tracking System
COAL ASH DOE	Steam-Electric Plant Operation Data
COAL ASH EPA	Coal Combustion Residues Surface Impoundments List
PCB TRANSFORMER	PCB Transformer Registration Database
RADINFO	Radiation Information Database
HIST FTTS	FIFRA/TSCA Tracking System Administrative Case Listing
DOT OPS	Incident and Accident Data
CONSENT	Superfund (CERCLA) Consent Decrees
INDIAN RESERV	Indian Reservations
FUSRAP	Formerly Utilized Sites Remedial Action Program
UMTRA	Uranium Mill Tailings Sites
LEAD SMELTERS	Lead Smelter Sites
US AIRS	Aerometric Information Retrieval System Facility Subsystem
US MINES	Mines Master Index File
ABANDONED MINES	Abandoned Mines
FINDS	Facility Index System/Facility Registry System
ECHO	Enforcement & Compliance History Information
UXO	Unexploded Ordnance Sites
DOCKET HWC	Hazardous Waste Compliance Docket Listing
FUELS PROGRAM	EPA Fuels Program Registered Listing
AIRS	Oregon Title V Facility Listing
COAL ASH	Coal Ash Disposal Sites Listing
DRYCLEANERS	Drycleaning Facilities
Enforcement	Enforcement Action Listing
Financial Assurance	Financial Assurance Information Listing
MANIFEST	Manifest Information
NPDES	Wastewater Permits Database

EDR HIGH RISK HISTORICAL RECORDS

EDR Exclusive Records

EDR MGP	EDR Proprietary Manufactured Gas Plants
EDR Hist Auto	EDR Exclusive Historical Auto Stations
EDR Hist Cleaner	EDR Exclusive Historical Cleaners

EDR RECOVERED GOVERNMENT ARCHIVES

Exclusive Recovered Govt. Archives

RGA LF	Recovered Government Archive Solid Waste Facilities List

RGA LUST - - - - - - - - - - - - - - - - - - Recovered Government Archive Leaking Underground Storage Tank

SURROUNDING SITES: SEARCH RESULTS

Surrounding sites were identified in the following databases.

Elevations have been determined from the USGS Digital Elevation Model and should be evaluated on a relative (not an absolute) basis. Relative elevation information between sites of close proximity should be field verified. Sites with an elevation equal to or higher than the target property have been differentiated below from sites with an elevation lower than the target property.
Page numbers and map identification numbers refer to the EDR Radius Map report where detailed data on individual sites can be reviewed.

Sites listed in ***bold italics*** are in multiple databases.

Unmappable (orphan) sites are not considered in the foregoing analysis.

STANDARD ENVIRONMENTAL RECORDS

State- and tribal - equivalent CERCLIS

ECSI: The Environmental Cleanup Site Information System records information about sites in Oregon that may be of environmental interest. The data come from the Department of Environmental Quality.

A review of the ECSI list, as provided by EDR, and dated 10/01/2018 has revealed that there are 6 ECSI sites within approximately 1 mile of the target property.

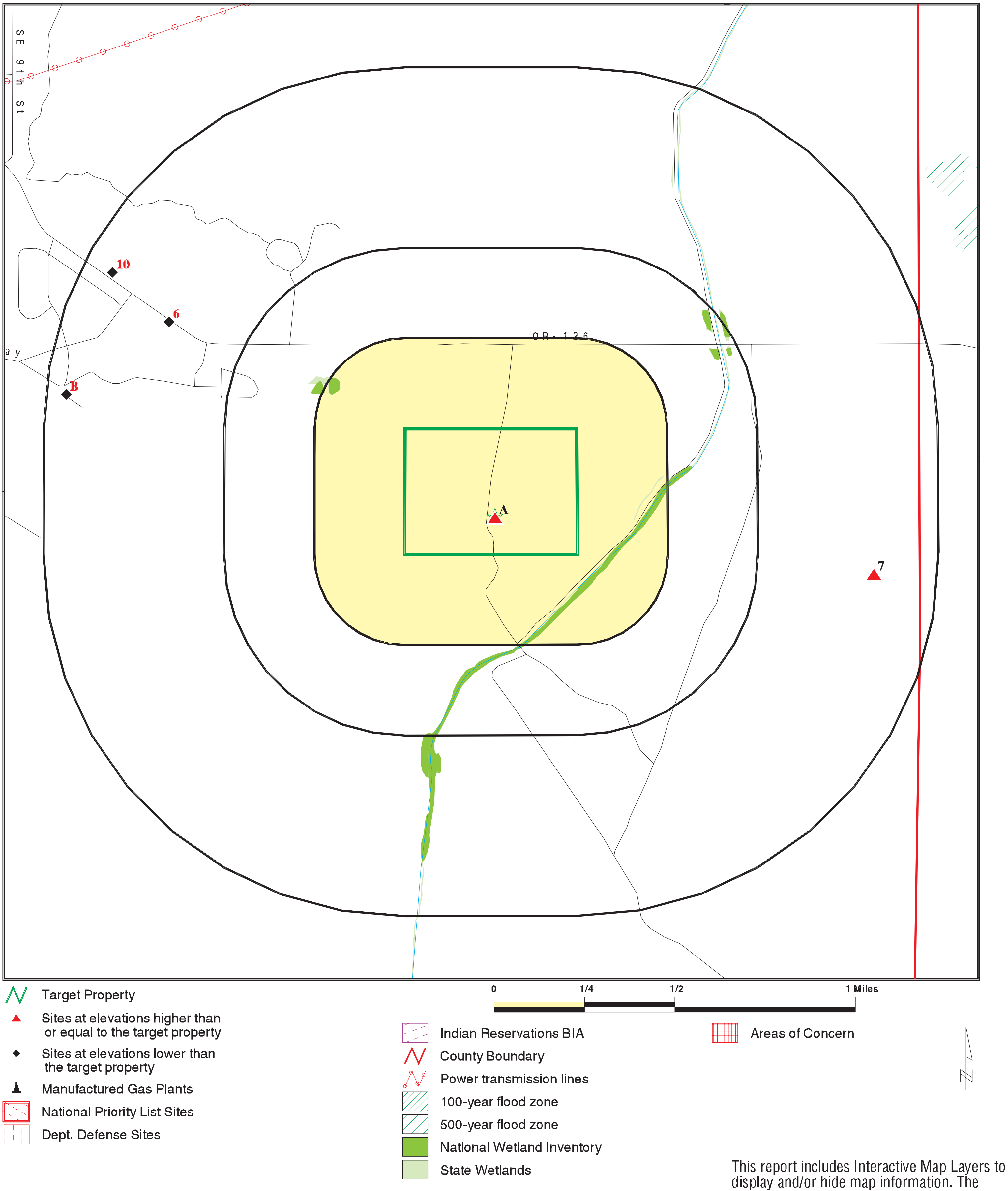
Equal/Higher Elevation	Address	Direction / Distance	Map ID	Page
BIAK TRAINING CENTER Investigation: No Further Action State ID Number: 5050 State ID Number: 5051		E 1/2 - 1 (0.823 mi.)	7	30

Lower Elevation	Address	Direction / Distance	Map ID	Page
DESCHUTES CO. PROPER Investigation: Suspect State ID Number: 4710 State ID Number: 5054	***2555 E HWY 126***	***WNW 1/2 - 1 (0.717 mi.)***	***6***	***25***
REDMOND MUNICIPAL AI Investigation: Suspect State ID Number: 5952	***1020-1050 SE SISTERS***	***WNW 1/2 - 1 (0.914 mi.)***	***B8***	***36***
REDMOND MUNICIPAL AI Investigation: Suspect State ID Number: 4103	1020 SE SISTERS AVE	WNW 1/2 - 1 (0.914 mi.)	B9	37
MAX MILLS FORMERLY O Investigation: No Further Action State ID Number: 3465	***HWY 126 (BTWN 27TH &***	***WNW 1/2 - 1 (0.918 mi.)***	***10***	***41***
DESCHUTES READY MIX Investigation: No Further Action State ID Number: 2637	***700 SW SISTERS AVE***	***WNW 1/2 - 1 (0.942 mi.)***	***B11***	***43***

EXECUTIVE SUMMARY

There were no unmapped sites in this report.

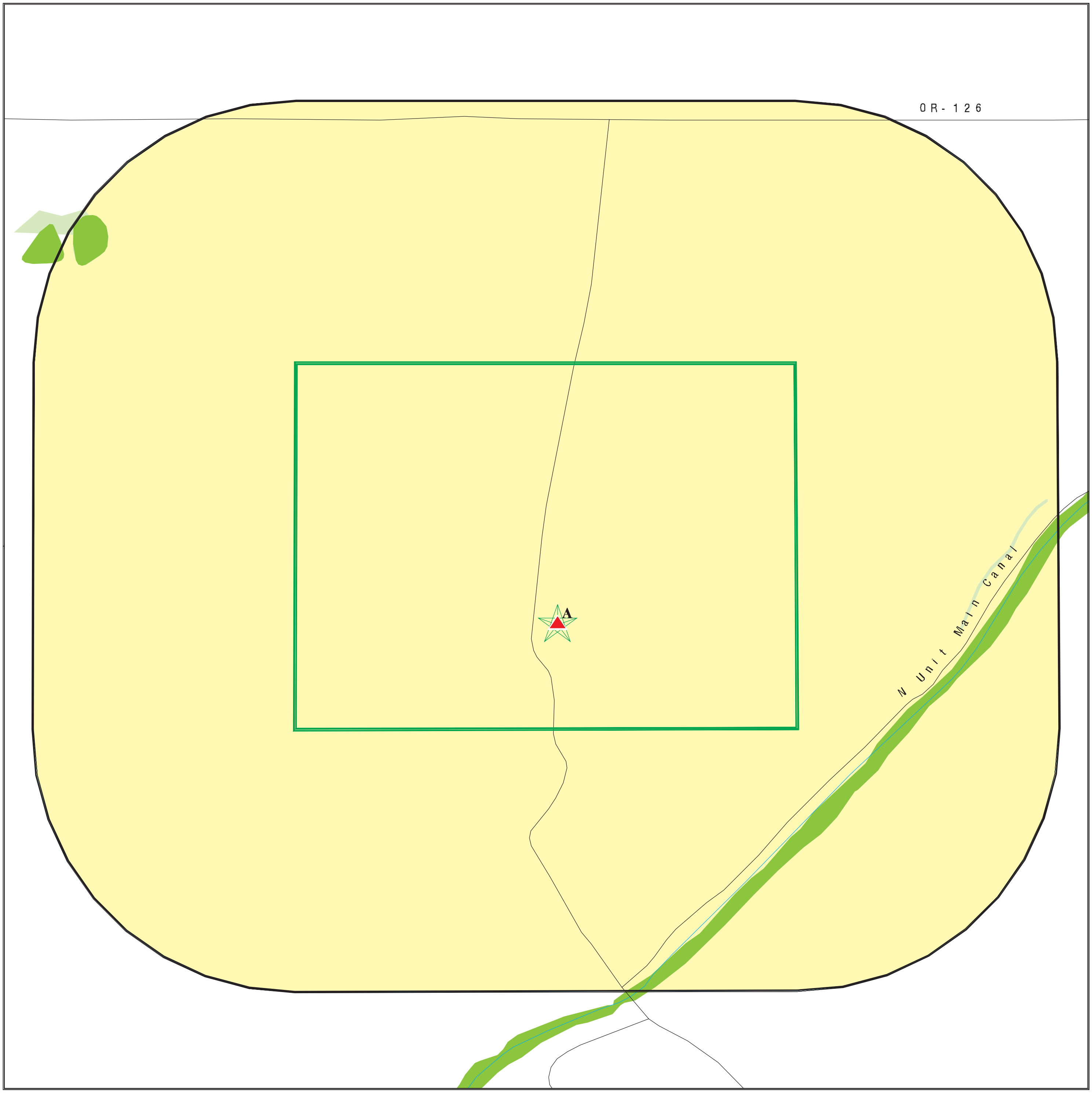
OVERVIEW MAP - 5464928.2S



This report includes Interactive Map Layers to display and/or hide map information. The legend includes only those icons for the default map view.

SITE NAME: Redmond BIAK COUTES	CLIENT: AECOM
ADDRESS: 2522 SE Jesse Butler Cir Redmond OR 97756	CONTACT: Brittany Kirchmann
	INQUIRY #: 5464928.2s
LAT/LONG: 44.255065 / 121.131854	DATE: October 25, 2018 11:40 am

DETAIL MAP - 5464928.2S



0 1/8 1/4 1/2 Miles

- 🟩 Target Property
- ▲ Sites at elevations higher than or equal to the target property
- ◆ Sites at elevations lower than the target property
- ♟ Manufactured Gas Plants
- ▪ Sensitive Receptors
- ▨ National Priority List Sites
- ▨ Dept. Defense Sites
- ▨ Indian Reservations BIA
- ▨ 100-year flood zone
- ▨ 500-year flood zone
- 🟩 National Wetland Inventory
- 🟩 State Wetlands
- ▦ Areas of Concern

This report includes Interactive Map Layers to display and/or hide map information. The legend includes only those icons for the default map view.

SITE NAME: Redmond BIAK COUTES
ADDRESS: 2522 SE Jesse Butler Cir
Redmond OR 97756
LAT/LONG: 44.255065 / 121.131854

CLIENT: AECOM
CONTACT: Brittany Kirchmann
INQUIRY #: 5464928.2s
DATE: October 25, 2018 11:42 am

MAP FINDINGS SUMMARY

Database	Search Distance (Miles)	Target Property	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
STANDARD ENVIRONMENTAL RECORDS								
Federal NPL site list								
NPL	1.000		0	0	0	0	NR	0
Proposed NPL	1.000		0	0	0	0	NR	0
NPL LIENS	TP		NR	NR	NR	NR	NR	0
Federal Delisted NPL site list								
Delisted NPL	1.000		0	0	0	0	NR	0
Federal CERCLIS list								
FEDERAL FACILITY	0.500		0	0	0	NR	NR	0
SEMS	0.500		0	0	0	NR	NR	0
Federal CERCLIS NFRAP site list								
SEMS-ARCHIVE	0.500		0	0	0	NR	NR	0
Federal RCRA CORRACTS facilities list								
CORRACTS	1.000		0	0	0	0	NR	0
Federal RCRA non-CORRACTS TSD facilities list								
RCRA-TSDF	0.500		0	0	0	NR	NR	0
Federal RCRA generators list								
RCRA-LQG	0.250		0	0	NR	NR	NR	0
RCRA-SQG	0.250		0	0	NR	NR	NR	0
RCRA-CESQG	0.250		0	0	NR	NR	NR	0
Federal institutional controls / engineering controls registries								
LUCIS	0.500		0	0	0	NR	NR	0
US ENG CONTROLS	0.500		0	0	0	NR	NR	0
US INST CONTROL	0.500		0	0	0	NR	NR	0
Federal ERNS list								
ERNS	TP		NR	NR	NR	NR	NR	0
State- and tribal - equivalent CERCLIS								
ECSI	1.000	1	0	0	0	6	NR	7
CRL	1.000		0	0	0	0	NR	0
State and tribal landfill and/or solid waste disposal site lists								
SWF/LF	0.500		0	0	0	NR	NR	0
State and tribal leaking storage tank lists								
LUST	0.500		0	0	0	NR	NR	0
INDIAN LUST	0.500		0	0	0	NR	NR	0
State and tribal registered storage tank lists								
FEMA UST	0.250		0	0	NR	NR	NR	0

MAP FINDINGS SUMMARY

Database	Search Distance (Miles)	Target Property	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
UST	0.250		0	0	NR	NR	NR	0
AST	0.250	1	0	0	NR	NR	NR	1
INDIAN UST	0.250		0	0	NR	NR	NR	0
State and tribal institutional control / engineering control registries								
ENG CONTROLS	0.500		0	0	0	NR	NR	0
INST CONTROL	0.500		0	0	0	NR	NR	0
State and tribal voluntary cleanup sites								
INDIAN VCP	0.500		0	0	0	NR	NR	0
VCP	0.500	1	0	0	0	NR	NR	1
State and tribal Brownfields sites								
BROWNFIELDS	0.500		0	0	0	NR	NR	0
ADDITIONAL ENVIRONMENTAL RECORDS								
Local Brownfield lists								
US BROWNFIELDS	0.500		0	0	0	NR	NR	0
Local Lists of Landfill / Solid Waste Disposal Sites								
HIST LF	0.500		0	0	0	NR	NR	0
SWRCY	0.500		0	0	0	NR	NR	0
INDIAN ODI	0.500		0	0	0	NR	NR	0
ODI	0.500		0	0	0	NR	NR	0
DEBRIS REGION 9	0.500		0	0	0	NR	NR	0
IHS OPEN DUMPS	0.500		0	0	0	NR	NR	0
Local Lists of Hazardous waste / Contaminated Sites								
US HIST CDL	TP		NR	NR	NR	NR	NR	0
AOCONCERN	1.000		0	0	0	0	NR	0
CDL	TP		NR	NR	NR	NR	NR	0
US CDL	TP		NR	NR	NR	NR	NR	0
Local Land Records								
LIENS 2	TP		NR	NR	NR	NR	NR	0
Records of Emergency Release Reports								
HMIRS	TP		NR	NR	NR	NR	NR	0
SPILLS	TP		NR	NR	NR	NR	NR	0
OR HAZMAT	TP	2	NR	NR	NR	NR	NR	2
SPILLS 90	TP		NR	NR	NR	NR	NR	0
Other Ascertainable Records								
RCRA NonGen / NLR	0.250		0	0	NR	NR	NR	0
FUDS	1.000		0	0	0	0	NR	0
DOD	1.000		0	0	0	0	NR	0

MAP FINDINGS SUMMARY

Database	Search Distance (Miles)	Target Property	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
SCRD DRYCLEANERS	0.500		0	0	0	NR	NR	0
US FIN ASSUR	TP		NR	NR	NR	NR	NR	0
EPA WATCH LIST	TP		NR	NR	NR	NR	NR	0
2020 COR ACTION	0.250		0	0	NR	NR	NR	0
TSCA	TP		NR	NR	NR	NR	NR	0
TRIS	TP		NR	NR	NR	NR	NR	0
SSTS	TP		NR	NR	NR	NR	NR	0
ROD	1.000		0	0	0	0	NR	0
RMP	TP		NR	NR	NR	NR	NR	0
RAATS	TP		NR	NR	NR	NR	NR	0
PRP	TP		NR	NR	NR	NR	NR	0
PADS	TP		NR	NR	NR	NR	NR	0
ICIS	TP		NR	NR	NR	NR	NR	0
FTTS	TP		NR	NR	NR	NR	NR	0
MLTS	TP		NR	NR	NR	NR	NR	0
COAL ASH DOE	TP		NR	NR	NR	NR	NR	0
COAL ASH EPA	0.500		0	0	0	NR	NR	0
PCB TRANSFORMER	TP		NR	NR	NR	NR	NR	0
RADINFO	TP		NR	NR	NR	NR	NR	0
HIST FTTS	TP		NR	NR	NR	NR	NR	0
DOT OPS	TP		NR	NR	NR	NR	NR	0
CONSENT	1.000		0	0	0	0	NR	0
INDIAN RESERV	1.000		0	0	0	0	NR	0
FUSRAP	1.000		0	0	0	0	NR	0
UMTRA	0.500		0	0	0	NR	NR	0
LEAD SMELTERS	TP		NR	NR	NR	NR	NR	0
US AIRS	TP		NR	NR	NR	NR	NR	0
US MINES	0.250		0	0	NR	NR	NR	0
ABANDONED MINES	0.250		0	0	NR	NR	NR	0
FINDS	TP		NR	NR	NR	NR	NR	0
ECHO	TP		NR	NR	NR	NR	NR	0
UXO	1.000		0	0	0	0	NR	0
DOCKET HWC	TP		NR	NR	NR	NR	NR	0
FUELS PROGRAM	0.250		0	0	NR	NR	NR	0
AIRS	TP		NR	NR	NR	NR	NR	0
COAL ASH	0.500		0	0	0	NR	NR	0
DRYCLEANERS	0.250		0	0	NR	NR	NR	0
Enforcement	TP		NR	NR	NR	NR	NR	0
Financial Assurance	TP		NR	NR	NR	NR	NR	0
HSIS	TP	1	NR	NR	NR	NR	NR	1
MANIFEST	0.250		0	0	NR	NR	NR	0
NPDES	TP		NR	NR	NR	NR	NR	0
UIC	TP	1	NR	NR	NR	NR	NR	1

EDR HIGH RISK HISTORICAL RECORDS

EDR Exclusive Records

Database	Search Distance (Miles)	Target Property	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
EDR MGP	1.000		0	0	0	0	NR	0
EDR Hist Auto	0.125		0	NR	NR	NR	NR	0
EDR Hist Cleaner	0.125		0	NR	NR	NR	NR	0

MAP FINDINGS SUMMARY

Database	Search Distance (Miles)	Target Property	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
EDR RECOVERED GOVERNMENT ARCHIVES								
Exclusive Recovered Govt. Archives								
RGA HWS	TP	1	NR	NR	NR	NR	NR	1
RGA LF	TP		NR	NR	NR	NR	NR	0
RGA LUST	TP		NR	NR	NR	NR	NR	0
- Totals --		8	0	0	0	6	0	14

NOTES:

TP = Target Property

NR = Not Requested at this Search Distance

Sites may be listed in more than one database

A1 **Target** **Property**	**2522 SE JESSE BUTLER CIR** **REDMOND, OR 97756**	**OR HAZMAT**	**S116497164** **N/A**

Site 1 of 5 in cluster A

Actual:
3069 ft.

HAZMAT:

Responsble Party:	Not reported
RP Company:	Not reported
RP Address:	Not reported
RP City,St,Zip:	Not reported
Facility ID:	1440852
OERS Number:	Not reported
Dept Rsp:	Not reported
Narrative:	Not reported
Property Loss:	Not reported
Amount Released:	Not reported
Service County:	Not reported
Service Name:	REDMOND F&R
Incident Type:	Not reported
Civilian Casualty Activity:	Not reported
Chemical Name:	Not reported
Hazmat Area Affected:	Not reported
Hazmat Area Evacuated:	Not reported
Hazmat Container Type:	Not reported
Hazmat Physical State Released:	Not reported
Hazmat Released Into:	Not reported
Hazmat Released Volume Units:	Not reported
Hazmat Released Weight Units:	Not reported
Hazmat Released From:	Not reported
Hazmat Area Affected Measurement:	Not reported
Hazmat No. of People Evacuated:	Not reported
Hazmat No of Buildings Evacuated:	Not reported
Incident Content Loss:	Not reported
Civilian Casualty Patient Disposition:	Not reported
Incident Mixed Use Property:	Not reported
Location Type:	Adjacent to
Incident Aid Given Or Received:	None
Incident AID Received from FDID:	False
Incident Aided Department FDID:	Not reported
Person Involved Business Name:	Not reported
Person Involved First Name:	Not reported
Person Involved Last Name:	Not reported
Person Involved Type:	Not reported
Person Involved Phone Number:	Not reported
Person Involved Primary Language:	Not reported
Hazmat Evacuated Measurement:	Not reported
Hazmat Story of Release:	Not reported
Remark:	ARFF 1, 412, 421 disp to Butler ramp for fuel spill from a CH47 TN 00237. Spill was approximately 6 gallons, airport maintenance handled the incident by applying absorbent over the spill area.
Incident District:	Not reported
Date Added:	Not reported
Unit:	Not reported
Agency Phone:	Not reported
Osfm Incident Report Number:	1440852
Dept. Responding:	Not reported
Person Making Report:	Not reported
Title:	Not reported

(Continued) **S116497164**

Agency: Not reported
Phone: Not reported
Date Of Incident: 03/11/2014
Call Time: 12:40
In Route: Not reported
Arrival: Not reported
Depart Scene: Not reported
Back In Quarters: Not reported
In Service: Not reported
Dist Of Incident: Not reported
Were State Resources Used?: Not reported
Was Oers Notified?: Not reported
Oers Number: Not reported
Team Number: Not reported
Agency Report Number: Not reported
Unit: Not reported
Highway: Not reported
Mile Post: Not reported
Scene Type: Not reported
Area Type: Not reported
Responsible Party(Ies): Not reported
Company: Not reported
Respcontact: Not reported
Address: Not reported
Resp City: Not reported
Resp State: Not reported
Resp ZipCode: Not reported
Phone: Not reported
Resp Phone2: Not reported
Weather: Not reported
Temperature: Not reported
Wind Speed: Not reported
Wind Direction: Not reported
Were Haz Materials Released?: Not reported
Operation Performed: Not reported
Cause: Not reported
Vehicle And Cargo: Not reported
Fixed Property: Not reported
Total Loss: Not reported
Hazmat Population Density: Not reported
HazMat Actions Taken - Description: Not reported
Hazmat Factors Contributing To Release: Not reported
Hazmat DOT Hazard Classification: Not reported
Hazmat CAS Number: Not reported
Hazardous Materials Release: Not reported
Fire Incident Type: Gasoline or other flammable liquid spill
Property Use: Aircraft loading area
Latitude: Not reported
Longitude: Not reported
Hazmat Disposition: Not reported

Responsble Party: Not reported
RP Company: Not reported
RP Address: Not reported
RP City,St,Zip: Not reported
Facility ID: 1440852
OERS Number: Not reported

(Continued) **S116497164**

Dept Rsp:	Not reported
Narrative:	Not reported
Property Loss:	Not reported
Amount Released:	Not reported
Service County:	Not reported
Service Name:	REDMOND F&R
Incident Type:	Not reported
Civilian Casualty Activity:	Not reported
Chemical Name:	Not reported
Hazmat Area Affected:	Not reported
Hazmat Area Evacuated:	Not reported
Hazmat Container Type:	Not reported
Hazmat Physical State Released:	Not reported
Hazmat Released Into:	Not reported
Hazmat Released Volume Units:	Not reported
Hazmat Released Weight Units:	Not reported
Hazmat Released From:	Not reported
Hazmat Area Affected Measurement:	Not reported
Hazmat No. of People Evacuated:	Not reported
Hazmat No of Buildings Evacuated:	Not reported
Incident Content Loss:	Not reported
Civilian Casualty Patient Disposition:	Not reported
Incident Mixed Use Property:	Not reported
Location Type:	Adjacent to
Incident Aid Given Or Received:	None
Incident AID Received from FDID:	False
Incident Aided Department FDID:	Not reported
Person Involved Business Name:	Not reported
Person Involved First Name:	Not reported
Person Involved Last Name:	Not reported
Person Involved Type:	Not reported
Person Involved Phone Number:	Not reported
Person Involved Primary Language:	Not reported
Hazmat Evacuated Measurement:	Not reported
Hazmat Story of Release:	Not reported
Remark:	ARFF 1, 412, 421 disp to Butler ramp for fuel spill from a CH47 TN 00237. Spill was approximately 6 gallons, airport maintenance handled the incident by applying absorbent over the spill area.
Incident District:	Not reported
Date Added:	Not reported
Unit:	Not reported
Agency Phone:	Not reported
Osfm Incident Report Number:	1440852
Dept. Responding:	Not reported
Person Making Report:	Not reported
Title:	Not reported
Agency:	Not reported
Phone:	Not reported
Date Of Incident:	03/11/2014
Call Time:	12:40
In Route:	Not reported
Arrival:	Not reported
Depart Scene:	Not reported
Back In Quarters:	Not reported
In Service:	Not reported
Dist Of Incident:	Not reported
Were State Resources Used?:	Not reported

(Continued) **S116497164**

Was Oers Notified?:	Not reported
Oers Number:	Not reported
Team Number:	Not reported
Agency Report Number:	Not reported
Unit:	Not reported
Highway:	Not reported
Mile Post:	Not reported
Scene Type:	Not reported
Area Type:	Not reported
Responsible Party(Ies):	Not reported
Company:	Not reported
Respcontact:	Not reported
Address:	Not reported
Resp City:	Not reported
Resp State:	Not reported
Resp ZipCode:	Not reported
Phone:	Not reported
Resp Phone2:	Not reported
Weather:	Not reported
Temperature:	Not reported
Wind Speed:	Not reported
Wind Direction:	Not reported
Were Haz Materials Released?:	Not reported
Operation Performed:	Not reported
Cause:	Not reported
Vehicle And Cargo:	Not reported
Fixed Property:	Not reported
Total Loss:	Not reported
Hazmat Population Density:	Not reported
HazMat Actions Taken - Description:	Not reported
Hazmat Factors Contributing To Release:	Not reported
Hazmat DOT Hazard Classification:	Not reported
Hazmat CAS Number:	Not reported
Hazardous Materials Release:	Not reported
Fire Incident Type:	Gasoline or other flammable liquid spill
Property Use:	Aircraft loading area
Latitude:	Not reported
Longitude:	Not reported
Hazmat Disposition:	Not reported

Responsble Party:	Not reported
RP Company:	Not reported
RP Address:	Not reported
RP City,St,Zip:	Not reported
Facility ID:	1440852
OERS Number:	Not reported
Dept Rsp:	Not reported
Narrative:	Not reported
Property Loss:	Not reported
Amount Released:	Not reported
Service County:	Not reported
Service Name:	REDMOND F&R
Incident Type:	Not reported
Civilian Casualty Activity:	Not reported
Chemical Name:	Not reported
Hazmat Area Affected:	Not reported
Hazmat Area Evacuated:	Not reported

(Continued) **S116497164**

Hazmat Container Type:	Not reported
Hazmat Physical State Released:	Not reported
Hazmat Released Into:	Not reported
Hazmat Released Volume Units:	Not reported
Hazmat Released Weight Units:	Not reported
Hazmat Released From:	Not reported
Hazmat Area Affected Measurement:	Not reported
Hazmat No. of People Evacuated:	Not reported
Hazmat No of Buildings Evacuated:	Not reported
Incident Content Loss:	Not reported
Civilian Casualty Patient Disposition:	Not reported
Incident Mixed Use Property:	Not reported
Location Type:	Adjacent to
Incident Aid Given Or Received:	None
Incident AID Received from FDID:	False
Incident Aided Department FDID:	Not reported
Person Involved Business Name:	Not reported
Person Involved First Name:	Not reported
Person Involved Last Name:	Not reported
Person Involved Type:	Not reported
Person Involved Phone Number:	Not reported
Person Involved Primary Language:	Not reported
Hazmat Evacuated Measurement:	Not reported
Hazmat Story of Release:	Not reported
Remark:	ARFF 1, 412, 421 disp to Butler ramp for fuel spill from a CH47 TN 00237. Spill was approximately 6 gallons, airport maintenance handled the incident by applying absorbent over the spill area.
Incident District:	Not reported
Date Added:	Not reported
Unit:	Not reported
Agency Phone:	Not reported
Osfm Incident Report Number:	1440852
Dept. Responding:	Not reported
Person Making Report:	Not reported
Title:	Not reported
Agency:	Not reported
Phone:	Not reported
Date Of Incident:	03/11/2014
Call Time:	12:40
In Route:	Not reported
Arrival:	Not reported
Depart Scene:	Not reported
Back In Quarters:	Not reported
In Service:	Not reported
Dist Of Incident:	Not reported
Were State Resources Used?:	Not reported
Was Oers Notified?:	Not reported
Oers Number:	Not reported
Team Number:	Not reported
Agency Report Number:	Not reported
Unit:	Not reported
Highway:	Not reported
Mile Post:	Not reported
Scene Type:	Not reported
Area Type:	Not reported
Responsible Party(Ies):	Not reported
Company:	Not reported

(Continued) **S116497164**

Respcontact:	Not reported
Address:	Not reported
Resp City:	Not reported
Resp State:	Not reported
Resp ZipCode:	Not reported
Phone:	Not reported
Resp Phone2:	Not reported
Weather:	Not reported
Temperature:	Not reported
Wind Speed:	Not reported
Wind Direction:	Not reported
Were Haz Materials Released?:	Not reported
Operation Performed:	Not reported
Cause:	Not reported
Vehicle And Cargo:	Not reported
Fixed Property:	Not reported
Total Loss:	Not reported
Hazmat Population Density:	Not reported
HazMat Actions Taken - Description:	Not reported
Hazmat Factors Contributing To Release:	Not reported
Hazmat DOT Hazard Classification:	Not reported
Hazmat CAS Number:	Not reported
Hazardous Materials Release:	Not reported
Fire Incident Type:	Gasoline or other flammable liquid spill
Property Use:	Aircraft loading area
Latitude:	Not reported
Longitude:	Not reported
Hazmat Disposition:	Not reported

A2 **ROBERTS FIELD TERMINAL EXPANSION** **RGA HWS** **S115337358**
Target **2522 SE JESSE BUTLER CIRCLE # 17** **N/A**
Property **REDMOND, OR**

Site 2 of 5 in cluster A

Actual:
3069 ft.

RGA HWS:

2012	ROBERTS FIELD TERMINAL EXPANSION	2522 SE JESSE BUTLER CIRCLE # 17
2011	ROBERTS FIELD TERMINAL EXPANSION	2522 SE JESSE BUTLER CIRCLE # 17
2010	ROBERTS FIELD TERMINAL EXPANSION	2522 SE JESSE BUTLER CIRCLE # 17
2009	ROBERTS FIELD TERMINAL EXPANSION	2522 SE JESSE BUTLER CIRCLE # 17

A3 **REDMOND MUNICIPAL AIRPORT -ETHYLENE GLYCOL RELEASE** **ECSI** **S111242923**
Target **2522 SE JESSE BUTLER CIRCLE #17** **VCP** **N/A**
Property **REDMOND, OR 97756** **UIC**

Site 3 of 5 in cluster A

Actual:
3069 ft.

ECSI:

State ID Number:	5121
Brown ID:	0
Study Area:	False
Region ID:	1
Legislatve ID:	831

REDMOND MUNICIPAL AIRPORT -ETHYLENE GLYCOL RELEASE (Continued) **S111242923**

Investigation:	No Further Action
FACA ID:	125626
Further Action:	0
Lat/Long (dms):	44 15 11.90 / -121 9 41.40
County Code:	9.00
Score Value:	Not reported
Cerclis ID:	Not reported
Township Coord.:	15.00
Township Zone:	S
Range Coord:	13.00
Range Zone:	E
Section Coord:	22
Qtr Section:	Not reported
Tax Lots:	Not reported
Size:	Not reported
NPL:	False
Orphan:	False
Updated By:	KROBERT
Update Date:	05/18/2015
Created Date:	01/06/2009
Decode For RegionID:	Eastern Region
Decode For BrownID:	Not reported
Decode For Furtheract:	Not reported
Decode For Investstat:	No Further Action
Decode For Legislative:	Owner, operator or other party under agreement, order or consent decree under ORS 465.200 or 465.420
Alias Name:	Roberts Field Terminal Expansion

Narrative:

NARR ID:	5751080
NARR Code:	Site Contacts
Created By:	CWALKEY
Created Date:	01/06/2009
Updated By:	CWALKEY
Updated Date:	01/06/2009
Decode for NarcdID:	Site Contacts
NARR Comments:	Shannon Taylor (City of Remond) 541.504.5074 (office)

NARR ID:	5751079
NARR Code:	Contamination
Created By:	CWALKEY
Created Date:	01/06/2009
Updated By:	KROBERT
Updated Date:	05/18/2015
Decode for NarcdID:	Contamination
NARR Comments:	(5/18/2015 KJR/SAS) Excavation of soils related to the Robert’s Field Terminal Expansion indicate that site soils are the environmental media impacted by deicing compounds (Ethylene glycol and propylene glycol). There is no indication of impact to groundwater or surface water.

NARR ID:	5751301
NARR Code:	Land Use (Current/Reasonably Likely)
Created By:	CWALKEY
Created Date:	03/25/2009
Updated By:	CWALKEY
Updated Date:	03/25/2009
Decode for NarcdID:	Land Use (Current/Reasonably Likely)

REDMOND MUNICIPAL AIRPORT -ETHYLENE GLYCOL RELEASE (Continued) **S111242923**

NARR Comments: Robert’s Field in a current municipal aviation facility.

NARR ID: 5751081
NARR Code: Media Contamination
Created By: CWALKEY
Created Date: 01/06/2009
Updated By: CWALKEY
Updated Date: 01/06/2009
Decode for NarcdID: Media Contamination
NARR Comments: Excavation of soils related to the Robert’s Field Terminal Expansion indicate that site soils are the environmental media impacted by deicing compounds. There is no indication of impact to groundwater or surface water.

NARR ID: 5751298
NARR Code: Remedial Action
Created By: CWALKEY
Created Date: 03/25/2009
Updated By: KROBERT
Updated Date: 05/18/2015
Decode for NarcdID: Remedial Action
NARR Comments: (3/25/2009 WCW/VCP) Site soils containing ethylene and/or propylene glycol compounds were excavated and staged in conjunction with a planned expansion of the Robert’s Field terminal expansion construction project during May, June, and July 2008. Staged spoil piles were evaluated analytically to inform decisions about soil management. At the City of Redmond’s request, DEQ evaluated the residual risk of these compounds to potential receptors of concern. DEQ concluded that additional investigation and/or remedial action was not required.

NARR ID: 5751299
NARR Code: Residual Risk Assessment
Created By: CWALKEY
Created Date: 03/25/2009
Updated By: CWALKEY
Updated Date: 03/25/2009
Decode for NarcdID: Residual Risk Assessment
NARR Comments: DEQ concluded that additional remedial action is not required (DEQ, January 30, 2009).

NARR ID: 5751300
NARR Code: 1922
Created By: CWALKEY
Created Date: 03/25/2009
Updated By: KROBERT
Updated Date: 05/18/2015
Decode for NarcdID: Current Site Summary Statement
NARR Comments: At the City of Redmond’s request, DEQ provided an assessment of residual risk following a City-sponsored Interim Removal Action. DEQ documented this residual risk in a technical memorandum (DEQ, January 30, 2009).

Administrative Action:
Action ID: 9469
Region: Eastern Region
Complete Date: 01/30/2009
Rank Value: Not reported

REDMOND MUNICIPAL AIRPORT -ETHYLENE GLYCOL RELEASE (Continued) **S111242923**

Cleanup Flag: False
Created Date: 05/15/2015
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Remedial Action
Action Code Flag: False
Action: REMEDIAL ACTION
Further Action: 0
Comments: Not reported

Action ID: 9443
Region: Eastern Region
Complete Date: 01/30/2009
Rank Value: Not reported
Cleanup Flag: False
Created Date: 05/18/2015
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Remedial Action
Action Code Flag: False
Action: NO FURTHER STATE ACTION REQUIRED
Further Action: 0
Comments: Not reported

Action ID: 9424
Region: Not reported
Complete Date: 01/06/2009
Rank Value: Not reported
Cleanup Flag: False
Created Date: 01/06/2009
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Not reported
Category: Administrative Action
Action Code Flag: False
Action: Site added to database
Further Action: Not reported
Comments: Not reported

VCS:
ECS Site ID: 5121
Facility Size: Not reported
Action: NO FURTHER STATE ACTION REQUIRED
Start Date: 01/30/2009
End Date: 01/30/2009
Facility Status: Completed
Program: VCP
Latitude: 44.2533
Longitude: -121.1615

OR UIC:
UIC Well #: 1
Type: 5D2
Type Description: Storm Water Drainage
Status: Active
UIC Number: 12415
Facility Status: Applied for permit

REDMOND MUNICIPAL AIRPORT -ETHYLENE GLYCOL RELEASE (Continued) **S111242923**

Lat/Long:	44.252998 / -121.1606

UIC Well #:	2
Type:	5D2
Type Description:	Storm Water Drainage
Status:	Active
UIC Number:	12415
Facility Status:	Applied for permit
Lat/Long:	44.252998 / -121.1606

A4
Target
Property

REDMOND CITY OF
2522 SE JESSE BUTLER CIR 17
REDMOND, OR 97756

AST **S105745181**
HSIS **N/A**

Site 4 of 5 in cluster A

Actual:
3069 ft.

AST:

Facility Id:	033518
Hazardous Substance:	DIESEL
Reporting Quantities:	1,000-4,999
Quantity Units:	GALLONS
Physical State:	LIQUID
Storage 1:	ABOVEGROUND TANK

HSIS:

Facility ID:	033518
Department Or Division Of Company:	ROBERTS FIELD
Extremely Hazardous Substance:	N
Facility Has Written Emergency Plan:	Y
Contains 112R:	N
NAICS Code 1:	921190
NAICS Desc 1:	OTHER GENERAL GOV SUPPORT
NAICS Code 2:	488119
NAICS Desc 2:	OTHER AIRPORT OPERATIONS
Manager Name:	ZACHARY BASS
Business Phone:	5415043499
Mailing Address:	2522 SE JESSE BUTLER CIR 17
Mailing City:	REDMOND
Mailing State:	OR
Mailing Zip:	977568643
No. of Employees:	18
Day Phone:	5419482906
Placard:	Y
Fire Dept Code:	0538
FD:	REDMOND FIRE AND RESCUE
Sprinkler System:	Y
Emergency Contact:	WINTON PLATT
Emergency Procedure:	ADMIN LIBRARY REDMOND fd
Business Type:	COMMERCIAL AIRPORT
Facility Type:	Not reported
Division/Department:	Not reported
Facility Status:	Not reported
Status TRI:	Not reported
Status RMP:	Not reported
Status PSM:	Not reported
Status CR2K:	Not reported
Status 302:	Not reported

REDMOND CITY OF (Continued) **S105745181**

Owner Name:	Not reported
Latest Report ID:	Not reported
Case Number:	Not reported
Chemical Name:	Not reported
EHS Name:	Not reported
Is Pure:	Not reported
Is Mix:	Not reported
Is EHS:	Not reported
Mixture Component:	Not reported
Maximum DailyAmount Code:	Not reported
Maximum DailyAmount Unit:	Not reported
Chemical Added Date:	Not reported
Is ChemPSM:	Not reported
Is Chem112r:	Not reported
Is Chem302:	Not reported
Is Pesticide:	Not reported
Is Fertilizer:	Not reported
Physical State:	Not reported
UNNA Number:	Not reported
NFPA Health:	Not reported
NFPA Flammability:	Not reported
NFPA Reactivity:	Not reported
NFPA Special Notice:	Not reported
Hazards:	Not reported
No# of Days Onsite:	Not reported
Latitude:	Not reported
Longitude:	Not reported

Facility:

Chemical Name:	DIESEL
Physical Description:	LIQUID
Case Number:	68476346
Facility Id:	033518
Physical State Of The Substance:	2
Avag Amt Possessed During Year CD:	20
Max Amt Possessed During Year CD:	20
Applicable Unit Of Measure Code:	2
Description Of The Unit Of Measure:	GALLONS
Type Code:	A
Description:	ABOVEGROUND TANK
Type Code:	Not reported
Temperature Description:	Not reported
Pressure of Code:	1
Pressure Description:	NORMAL PRESSURE
Pressure of Code:	Not reported
Pressure Description:	Not reported
Temperature Description:	NORMAL TEMPERATURE
Temperature of The Hazardous Substance Code:	4
Temperature Description:	Not reported
Temperature of The Hazardous Substance Code:	Not reported
Days Hazardous Substance On Site During Year:	365
Is The Substance Protected A Trade Secret:	False
Description Of The Max Qnty Code:	1,000-4,999
Description Of The Avg Qnty Code:	1,000-4,999
Most Hazardous Ingridient:	PETROLEUM DISTILLATES
United Nations/north America 4 Digit Class Number:	1202
Hazard Rank:	2
EHS Ingredient:	Not reported

REDMOND CITY OF (Continued) **S105745181**

Substance Pure: False
Substance Mix: True
First Hazardous Class Code For Chemical: Flammable and Combustible Liquid
Second Hazardous Class Code For Chemical: Acute Health Hazard
Third Hazardous Class Code For Chemical: Chronic Health Hazard
Hazard Class 1 Of The Chemical: 3.0
Hazard Class 2 Of The Chemical: 6.3
Hazard Class 3 Of The Chemical: 6.4

Chemical:
Chemical Name: DIESEL
United Nations/north America 4 Digit Class Number: 1202
Chemical Abstract Service Identifier Number: 68476346
Chemical Is Extremely Hazardous Substance (EHS): N
First Hazardous Class Code For Chemical: Flammable and Combustible Liquid
Second Hazardous Class Code For Chemical: Acute Health Hazard
Third Hazardous Class Code For Chemical: Chronic Health Hazard
Hazard Class 1 Of The Chemical: 3.0
Hazard Class 2 Of The Chemical: 6.3
Hazard Class 3 Of The Chemical: 6.4
Chemical Is A Toxic 313 Chemical: N
EPA Pesticide Registration Number: Not reported
Contains 112R: N
Contains EHS: N
Fertilizer: N
Pesticide: N
Contains 313: Y

A5 **OR HAZMAT** **S117403350**
Target **2522 SE JESSE BUTLER CIR** **N/A**
Property **REDMOND, OR 97756**

Site 5 of 5 in cluster A

Actual:
3069 ft.

HAZMAT:
Responsble Party: Not reported
RP Company: Not reported
RP Address: Not reported
RP City,St,Zip: Not reported
Facility ID: 1443274
OERS Number: Not reported
Dept Rsp: Not reported
Narrative: Not reported
Property Loss: Not reported
Amount Released: Not reported
Service County: Not reported
Service Name: REDMOND F&R
Incident Type: Not reported
Civilian Casualty Activity: Not reported
Chemical Name: Not reported
Hazmat Area Affected: Not reported
Hazmat Area Evacuated: Not reported
Hazmat Container Type: Not reported
Hazmat Physical State Released: Not reported
Hazmat Released Into: Not reported
Hazmat Released Volume Units: Not reported

(Continued) **S117403350**

Hazmat Released Weight Units: Not reported
Hazmat Released From: Not reported
Hazmat Area Affected Measurement: Not reported
Hazmat No. of People Evacuated: Not reported
Hazmat No of Buildings Evacuated: Not reported
Incident Content Loss: Not reported
Civilian Casualty Patient Disposition: Not reported
Incident Mixed Use Property: Not reported
Location Type: Street address
Incident Aid Given Or Received: None
Incident AID Received from FDID: False
Incident Aided Department FDID: Not reported
Person Involved Business Name: Not reported
Person Involved First Name: Not reported
Person Involved Last Name: Not reported
Person Involved Type: Not reported
Person Involved Phone Number: Not reported
Person Involved Primary Language: Not reported
Hazmat Evacuated Measurement: Not reported
Hazmat Story of Release: Not reported
Remark: 421 Fuel leaking from an auto. Found Nissan leaking gas after running over a deer. Put absorbant under auto. Stood by till towing company arrived. Once car was lifted by wrecker, placed patch over hole in tank stopping leak. Car left with tow company.
Incident District: Not reported
Date Added: Not reported
Unit: Not reported
Agency Phone: Not reported
Osfm Incident Report Number: 1443274
Dept. Responding: Not reported
Person Making Report: Not reported
Title: Not reported
Agency: Not reported
Phone: Not reported
Date Of Incident: 08/27/2014
Call Time: 23:49
In Route: Not reported
Arrival: Not reported
Depart Scene: Not reported
Back In Quarters: Not reported
In Service: Not reported
Dist Of Incident: Not reported
Were State Resources Used?: Not reported
Was Oers Notified?: Not reported
Oers Number: Not reported
Team Number: Not reported
Agency Report Number: Not reported
Unit: Not reported
Highway: Not reported
Mile Post: Not reported
Scene Type: Not reported
Area Type: Not reported
Responsible Party(Ies): Not reported
Company: Not reported
Respcontact: Not reported
Address: Not reported
Resp City: Not reported

(Continued) **S117403350**

Resp State: Not reported
Resp ZipCode: Not reported
Phone: Not reported
Resp Phone2: Not reported
Weather: Not reported
Temperature: Not reported
Wind Speed: Not reported
Wind Direction: Not reported
Were Haz Materials Released?: Not reported
Operation Performed: Not reported
Cause: Not reported
Vehicle And Cargo: Not reported
Fixed Property: Not reported
Total Loss: Not reported
Hazmat Population Density: Not reported
HazMat Actions Taken - Description: Not reported
Hazmat Factors Contributing To Release: Not reported
Hazmat DOT Hazard Classification: Not reported
Hazmat CAS Number: Not reported
Hazardous Materials Release: Not reported
Fire Incident Type: Gasoline or other flammable liquid spill
Property Use: 1 or 2 family dwelling
Latitude: Not reported
Longitude: Not reported
Hazmat Disposition: Not reported

Responsble Party: Not reported
RP Company: Not reported
RP Address: Not reported
RP City,St,Zip: Not reported
Facility ID: 1443274
OERS Number: Not reported
Dept Rsp: Not reported
Narrative: Not reported
Property Loss: Not reported
Amount Released: Not reported
Service County: Not reported
Service Name: REDMOND F&R
Incident Type: Not reported
Civilian Casualty Activity: Not reported
Chemical Name: Not reported
Hazmat Area Affected: Not reported
Hazmat Area Evacuated: Not reported
Hazmat Container Type: Not reported
Hazmat Physical State Released: Not reported
Hazmat Released Into: Not reported
Hazmat Released Volume Units: Not reported
Hazmat Released Weight Units: Not reported
Hazmat Released From: Not reported
Hazmat Area Affected Measurement: Not reported
Hazmat No. of People Evacuated: Not reported
Hazmat No of Buildings Evacuated: Not reported
Incident Content Loss: Not reported
Civilian Casualty Patient Disposition: Not reported
Incident Mixed Use Property: Not reported
Location Type: Street address
Incident Aid Given Or Received: None

(Continued) **S117403350**

Incident AID Received from FDID: False
Incident Aided Department FDID: Not reported
Person Involved Business Name: Not reported
Person Involved First Name: Not reported
Person Involved Last Name: Not reported
Person Involved Type: Not reported
Person Involved Phone Number: Not reported
Person Involved Primary Language: Not reported
Hazmat Evacuated Measurement: Not reported
Hazmat Story of Release: Not reported
Remark: 421 Fuel leaking from an auto. Found Nissan leaking gas after running over a deer. Put absorbant under auto. Stood by till towing company arrived. Once car was lifted by wrecker, placed patch over hole in tank stopping leak. Car left with tow company.
Incident District: Not reported
Date Added: Not reported
Unit: Not reported
Agency Phone: Not reported
Osfm Incident Report Number: 1443274
Dept. Responding: Not reported
Person Making Report: Not reported
Title: Not reported
Agency: Not reported
Phone: Not reported
Date Of Incident: 08/27/2014
Call Time: 23:49
In Route: Not reported
Arrival: Not reported
Depart Scene: Not reported
Back In Quarters: Not reported
In Service: Not reported
Dist Of Incident: Not reported
Were State Resources Used?: Not reported
Was Oers Notified?: Not reported
Oers Number: Not reported
Team Number: Not reported
Agency Report Number: Not reported
Unit: Not reported
Highway: Not reported
Mile Post: Not reported
Scene Type: Not reported
Area Type: Not reported
Responsible Party(Ies): Not reported
Company: Not reported
Respcontact: Not reported
Address: Not reported
Resp City: Not reported
Resp State: Not reported
Resp ZipCode: Not reported
Phone: Not reported
Resp Phone2: Not reported
Weather: Not reported
Temperature: Not reported
Wind Speed: Not reported
Wind Direction: Not reported
Were Haz Materials Released?: Not reported
Operation Performed: Not reported

(Continued) **S117403350**

Cause:	Not reported
Vehicle And Cargo:	Not reported
Fixed Property:	Not reported
Total Loss:	Not reported
Hazmat Population Density:	Not reported
HazMat Actions Taken - Description:	Not reported
Hazmat Factors Contributing To Release:	Not reported
Hazmat DOT Hazard Classification:	Not reported
Hazmat CAS Number:	Not reported
Hazardous Materials Release:	Not reported
Fire Incident Type:	Gasoline or other flammable liquid spill
Property Use:	1 or 2 family dwelling
Latitude:	Not reported
Longitude:	Not reported
Hazmat Disposition:	Not reported

Responsble Party:	Not reported
RP Company:	Not reported
RP Address:	Not reported
RP City,St,Zip:	Not reported
Facility ID:	1443274
OERS Number:	Not reported
Dept Rsp:	Not reported
Narrative:	Not reported
Property Loss:	Not reported
Amount Released:	Not reported
Service County:	Not reported
Service Name:	REDMOND F&R
Incident Type:	Not reported
Civilian Casualty Activity:	Not reported
Chemical Name:	Not reported
Hazmat Area Affected:	Not reported
Hazmat Area Evacuated:	Not reported
Hazmat Container Type:	Not reported
Hazmat Physical State Released:	Not reported
Hazmat Released Into:	Not reported
Hazmat Released Volume Units:	Not reported
Hazmat Released Weight Units:	Not reported
Hazmat Released From:	Not reported
Hazmat Area Affected Measurement:	Not reported
Hazmat No. of People Evacuated:	Not reported
Hazmat No of Buildings Evacuated:	Not reported
Incident Content Loss:	Not reported
Civilian Casualty Patient Disposition:	Not reported
Incident Mixed Use Property:	Not reported
Location Type:	Street address
Incident Aid Given Or Received:	None
Incident AID Received from FDID:	False
Incident Aided Department FDID:	Not reported
Person Involved Business Name:	Not reported
Person Involved First Name:	Not reported
Person Involved Last Name:	Not reported
Person Involved Type:	Not reported
Person Involved Phone Number:	Not reported
Person Involved Primary Language:	Not reported
Hazmat Evacuated Measurement:	Not reported
Hazmat Story of Release:	Not reported

(Continued) **S117403350**

Remark:	421 Fuel leaking from an auto. Found Nissan leaking gas after running over a deer. Put absorbant under auto. Stood by till towing company arrived. Once car was lifted by wrecker, placed patch over hole in tank stopping leak. Car left with tow company.
Incident District:	Not reported
Date Added:	Not reported
Unit:	Not reported
Agency Phone:	Not reported
Osfm Incident Report Number:	1443274
Dept. Responding:	Not reported
Person Making Report:	Not reported
Title:	Not reported
Agency:	Not reported
Phone:	Not reported
Date Of Incident:	08/27/2014
Call Time:	23:49
In Route:	Not reported
Arrival:	Not reported
Depart Scene:	Not reported
Back In Quarters:	Not reported
In Service:	Not reported
Dist Of Incident:	Not reported
Were State Resources Used?:	Not reported
Was Oers Notified?:	Not reported
Oers Number:	Not reported
Team Number:	Not reported
Agency Report Number:	Not reported
Unit:	Not reported
Highway:	Not reported
Mile Post:	Not reported
Scene Type:	Not reported
Area Type:	Not reported
Responsible Party(Ies):	Not reported
Company:	Not reported
Respcontact:	Not reported
Address:	Not reported
Resp City:	Not reported
Resp State:	Not reported
Resp ZipCode:	Not reported
Phone:	Not reported
Resp Phone2:	Not reported
Weather:	Not reported
Temperature:	Not reported
Wind Speed:	Not reported
Wind Direction:	Not reported
Were Haz Materials Released?:	Not reported
Operation Performed:	Not reported
Cause:	Not reported
Vehicle And Cargo:	Not reported
Fixed Property:	Not reported
Total Loss:	Not reported
Hazmat Population Density:	Not reported
HazMat Actions Taken - Description:	Not reported
Hazmat Factors Contributing To Release:	Not reported
Hazmat DOT Hazard Classification:	Not reported
Hazmat CAS Number:	Not reported
Hazardous Materials Release:	Not reported

(Continued) **S117403350**

Fire Incident Type: Gasoline or other flammable liquid spill
Property Use: 1 or 2 family dwelling
Latitude: Not reported
Longitude: Not reported
Hazmat Disposition: Not reported

6
WNW
1/2-1
0.717 mi.
3786 ft.

DESCHUTES CO. PROPERTY - TL 103
2555 E HWY 126
REDMOND, OR 97756

ECSI
BROWNFIELDS

S108169760
N/A

Relative:
Lower

Actual:
3055 ft.

ECSI:

State ID Number: 4710
Brown ID: 0
Study Area: False
Region ID: 1
Legislatve ID: 0
Investigation: Suspect
FACA ID: 98345
Further Action: 0
Lat/Long (dms): 44 15 48.60 / -121 8 12.80
County Code: 9.00
Score Value: Not reported
Cerclis ID: Not reported
Township Coord.: 15.00
Township Zone: S
Range Coord: 13.00
Range Zone: E
Section Coord: 14
Qtr Section: Not reported
Tax Lots: Not reported
Size: Not reported
NPL: False
Orphan: False
Updated By: DCROUSE
Update Date: 05/01/2009
Created Date: 09/19/2006
Decode For RegionID: Eastern Region
Decode For BrownID: Not reported
Decode For Furtheract: Not reported
Decode For Investstat: Suspect
Decode For Legislative: Not reported

Narrative:

NARR ID: 5748655
NARR Code: Contamination
Created By: DCROUSE
Created Date: 09/19/2006
Updated By: DCROUSE
Updated Date: 09/19/2006
Decode for NarcdID: Contamination
NARR Comments: (9/19/06 DMC/SAS) Site added for tracking as an active trap and skeet shooting range with sporting clays and pistol/rifle ranges.

NARR ID: 5748656
NARR Code: Data Sources
Created By: DCROUSE

DESCHUTES CO. PROPERTY - TL 103 (Continued) **S108169760**

Created Date: 09/19/2006
Updated By: DCROUSE
Updated Date: 09/19/2006
Decode for NarcdID: Data Sources
NARR Comments: 1. DMC/SAS driveby (8/7/06). 2. Internet website.

NARR ID: 5748657
NARR Code: Remedial Action
Created By: DCROUSE
Created Date: 09/19/2006
Updated By: DCROUSE
Updated Date: 09/19/2006
Decode for NarcdID: Remedial Action
NARR Comments: (9/19/06 DMC/SAS) Low priority screening recommended.

Administrative Action:
Action ID: 9424
Region: Not reported
Complete Date: 09/19/2006
Rank Value: Not reported
Cleanup Flag: False
Created Date: 09/19/2006
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Not reported
Category: Administrative Action
Action Code Flag: False
Action: Site added to database
Further Action: Not reported
Comments: Not reported

Action ID: 9508
Region: Eastern Region
Complete Date: 09/19/2006
Rank Value: Not reported
Cleanup Flag: False
Created Date: 09/19/2006
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Remedial Action
Action Code Flag: False
Action: Site Screening recommended (EV)
Further Action: 0
Comments: Not reported

Operations:
Operation Id: 135211
Operation Status: Active
Common Name: Redmond Rod & Gun Club
Yrs of Operation: Not reported
Comments: Active shooting range; dates of operation need to be verified.
Updated Date: 09/19/2006
Updated By: DCROUSE
Decode for OpstatID: Active
Operations SIC Id: 198664
SIC Code: 3482
Created By: DCROUSE
Created Date: 09/19/2006

DESCHUTES CO. PROPERTY - TL 103 (Continued) **S108169760**

State ID Number:	5054
Brown ID:	Brownfield Site - DEQ Funding Assistance
Study Area:	False
Region ID:	1
Legislatve ID:	0
Investigation:	Suspect
FACA ID:	108700
Further Action:	259
Lat/Long (dms):	44 15 50.80 / -121 8 32.30
County Code:	9.00
Score Value:	Not reported
Cerclis ID:	Not reported
Township Coord.:	15.00
Township Zone:	S
Range Coord:	13.00
Range Zone:	E
Section Coord:	14
Qtr Section:	Not reported
Tax Lots:	Sections 2, 11, 14 TL 103
Size:	215 acres
NPL:	False
Orphan:	False
Updated By:	GWISTAR
Update Date:	11/25/2014
Created Date:	08/22/2008
Decode For RegionID:	Eastern Region
Decode For BrownID:	Brownfield Site - DEQ Funding Assistance
Decode For Furtheract:	Medium-Low
Decode For Investstat:	Suspect
Decode For Legislative:	Not reported
Alias Name:	Sheriff’s Office Firearms Range

Narrative:

NARR ID:	5751494
NARR Code:	General Site Description
Created By:	GWISTAR
Created Date:	06/03/2009
Updated By:	GWISTAR
Updated Date:	06/03/2009
Decode for NarcdID:	General Site Description
NARR Comments:	The site is currently being incorporated into the City of Redmond’s Master Plan and is being re-zoned and platted. The scheduled future use is industrial and commercial. The identification of two firing ranges and a solid waste dump during the completion of a Phase I Environmental Site Assessment presents a redevelopment barrier to the County site. The extent of impacts from the dump and firing ranges are unknown and therefore cleanup costs are unknown. By defining the degree and extent of environmental concerns at the site, the County will be able to determine appropriate funding routes to address the cleanup actions that will likely be necessary at the two firing ranges and the dump.

NARR ID:	5751493
NARR Code:	Site Location
Created By:	GWISTAR
Created Date:	06/03/2009
Updated By:	GWISTAR
Updated Date:	06/03/2009

DESCHUTES CO. PROPERTY - TL 103 (Continued) **S108169760**

Decode for NarcdID: Site Location
NARR Comments: The site is a 215 acre parcel owned by Deschutes County and is located at 2555 E. Highway 126, Redmond, OR 97756 (T 15S; R: 13E ; S: 14 Tax Lot: 151300-00-00103).

NARR ID: 5751496
NARR Code: Manner of Release
Created By: GWISTAR
Created Date: 06/03/2009
Updated By: GWISTAR
Updated Date: 06/03/2009
Decode for NarcdID: Manner of Release
NARR Comments: The presence of an unpermitted solid waste site may also contain contaminants that may be present at levels of concern. Deschutes County also performed a Phase I ESA on the dump site. Based on a review of aerial photographs, the solid waste dump appeared after the property was transferred from Federal ownership. The dump may be the result of uncontrolled dumping post-1943 after the NWMA operations were concluded and likely consists of municipal waste.

NARR ID: 5750770
NARR Code: Remedial Action
Created By: KROBERT
Created Date: 08/22/2008
Updated By: KROBERT
Updated Date: 08/22/2008
Decode for NarcdID: Remedial Action
NARR Comments: (8/22/08 KJR/SAS) EPA approved DEQ performing a brownfield Site Specific Assessment on the property.

NARR ID: 5751495
NARR Code: Substances of Concern
Created By: GWISTAR
Created Date: 06/03/2009
Updated By: GWISTAR
Updated Date: 06/03/2009
Decode for NarcdID: Substances of Concern
NARR Comments: Lead and other metals from bullets and polynuclear aromatic hydrocarbons (PAHs) from clay pigeons.

NARR ID: 5750769
NARR Code: Site History
Created By: KROBERT
Created Date: 08/22/2008
Updated By: KROBERT
Updated Date: 08/22/2008
Decode for NarcdID: Site History
NARR Comments: The 215 acre property is a portion of the larger 500 acre Northwest Maneuver FUD Area. The property was determined to be surplus and transferred to Deschutes County from the Federal Government in BLM Patent 36-66-0010 dated July 27, 1965. Two firing ranges are located on the property. One ranged is used by County law enforcement and the other is leased to the Redmond Rod & Gun Club, a non-profit corporation. The firing ranges have been active for approximately 35 to 40 years.

NARR ID: 5751024

DESCHUTES CO. PROPERTY - TL 103 (Continued) **S108169760**

NARR Code: 1922
Created By: DANDERS
Created Date: 12/02/2008
Updated By: DANDERS
Updated Date: 07/31/2009
Decode for NarcdID: Current Site Summary Statement
NARR Comments: The site is a 215 acre parcel owned by Deschutes County and is located at 2555 E. Highway 126, Redmond, OR 97756 (T 15S; R: 13E ; S: 14 Tax Lot: 151300-00-00103). The site is currently being incorporated into the City of Redmond’s Master Plan and is being re-zoned and platted. The scheduled future use is industrial and commercial. Two firing ranges and a solid waste dump were identified during a Phase I Environmental Site Assessment. One ranged is used by County law enforcement and the other is leased to the Redmond Rod & Gun Club, a non-profit corporation. The firing ranges have been active for approximately 35 to 40 years. The presence of an un-permitted solid waste site also is of concern. DEQ and Deschutes County completd a Targeted Brownfield Assessment (TBA) at the site using EPA grant funding in March 2009. Contaminants of concern are lead and other metals from bullets, polynuclear aromatic hydrocarbons (PAHs) from clay pigeons, petroleum compounds, and PCBs from sludge disposed of at the solid wate site.

Administrative Action:

Action ID: 9506
Region: Eastern Region
Complete Date: 07/31/2009
Rank Value: Not reported
Cleanup Flag: False
Created Date: 11/25/2014
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Remedial Action
Action Code Flag: False
Action: Site Investigation recommended (SI)
Further Action: Medium-Low
Comments: Not reported

Action ID: 9424
Region: Not reported
Complete Date: 08/22/2008
Rank Value: Not reported
Cleanup Flag: False
Created Date: 08/22/2008
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Not reported
Category: Administrative Action
Action Code Flag: False
Action: Site added to database
Further Action: Not reported
Comments: Not reported

Action ID: 9518
Region: Eastern Region
Complete Date: 04/08/2009
Rank Value: Not reported
Cleanup Flag: False
Created Date: 08/22/2008

DESCHUTES CO. PROPERTY - TL 103 (Continued) **S108169760**

Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Remedial Action
Action Code Flag: False
Action: TARGETED BROWNFIELD ASSESSMENT
Further Action: 0
Comments: Not reported

OR BROWNFIELDS:
Geolocation Id: 108700
Status: Site Investigation recommended (SI)
Lat/Long: 44.2641 / -121.142

7
East
1/2-1
0.823 mi.
4344 ft.

BIAK TRAINING CENTER RANGE 2 **ECSI** **S109346110**
N/A

REDMOND, OR 97756

Relative:
Higher

Actual:
3077 ft.

ECSI:
State ID Number: 5050
Brown ID: 0
Study Area: False
Region ID: 1
Legislatve ID: 0
Investigation: No Further Action
FACA ID: 117730
Further Action: 0
Lat/Long (dms): 44 13 16.30 / -121 6 11.20
County Code: 9.00
Score Value: Not reported
Cerclis ID: Not reported
Township Coord.: 15.00
Township Zone: S
Range Coord: 13.00
Range Zone: E
Section Coord: 31
Qtr Section: Not reported
Tax Lots: Not reported
Size: 861.5 acres
NPL: False
Orphan: False
Updated By: GWISTAR
Update Date: 04/02/2013
Created Date: 08/11/2008
Decode For RegionID: Eastern Region
Decode For BrownID: Not reported
Decode For Furtheract: Not reported
Decode For Investstat: No Further Action
Decode For Legislative: Not reported

Narrative:
NARR ID: 5750727
NARR Code: Contamination
Created By: DCROUSE
Created Date: 08/11/2008
Updated By: DCROUSE
Updated Date: 08/11/2008

BIAK TRAINING CENTER RANGE 2 (Continued) **S109346110**

Decode for NarcdID: Contamination
NARR Comments: (8/11/08 DMC/SAS) Former range.

NARR ID: 5751650
NARR Code: Remedial Action
Created By: DANDERS
Created Date: 08/04/2009
Updated By: GWISTAR
Updated Date: 08/14/2009
Decode for NarcdID: Remedial Action
NARR Comments: Work included preparation of a Historical Records Review (HRR) document, technical project planning (TPP) meetings, preparation of a SI Work Plan, and SI fieldwork implementation and reporting. This range was used by the Oregon Army National Guard (ORARNG) to train troops on tracked and wheeled all-terrain vehicles and for infantry field training exercises consisting of land navigation, bivouacking, and temporary construction of fortifications and defensive positions. Training on the property involved the use of smoke grenades, artillery simulators and ground and aerial flares. No live firing was conducted on this range. This property is currently undeveloped, under the control of the Bureau of Land Management (BLM), and is fenced with locked gates. The SI results did not identify any risk or hazard at the range and no further action is needed to assure that site is protective of human health and the environment.

NARR ID: 5750960
NARR Code: 1922
Created By: DANDERS
Created Date: 11/03/2008
Updated By: DANDERS
Updated Date: 08/04/2009
Decode for NarcdID: Current Site Summary Statement
NARR Comments: BTC is located in Deschutes and Crook Counties, Oregon and currently consists of approximately 43,985 acres of federal public lands. The installation is approximately three miles southeast of the City of Redmond, Oregon and fourteen miles northeast of the City of Bend, Oregon. During World War II, the U.S. Army conducted training exercises on approximately 31,000 acres of U.S. Bureau of Land Management (BLM) land. BLM has continually issued a special use permit to the Oregon Army National Guard (ORARNG) since the 1960s to allow for military training at BTC. BTC was used as a maneuver area for tracked and wheeled all-terrain vehicles and for infantry field training exercises consisting of land navigation, bivouacking, and temporary construction of fortifications and defensive positions. These same activities still occur throughout the installation. Live fire exercises are not allowed at BTC, except at the small arms range located at the Central Oregon Unit Training Equipment Site (COUTES) within the Operational Range Area. BTC public lands remain open for public use. The primary public uses of BTC are livestock grazing, off-road vehicular recreation, target shooting, rockhounding, hiking, biking, and wildlife viewing. BTC has been referenced under different names in the past. These names include the Central Oregon Training Site, High Desert Training Center, and the Redmond Training Site. ORARNG refers to this installation as Biak Training Center. Two sites (Transferred Range 1 [ECSI #5050] and Transferred Range 2 [ECSI#5051]) were identified as MMRP eligible in previous investigations. Transferred Range 2 is FUDS eligible, but not active

BIAK TRAINING CENTER RANGE 2 (Continued) **S109346110**

Army MMRP eligible. Transferred Range 1 is being addressed under the active Army MMRP process. Transferred Range 1 is a 861.48 acre former range is located to the southeast of the current installation, on property that was leased from the BLM from approximately 1960 through 1980. The ORARNG never owned this land. This range was used by the ORARNG to train troops on tracked and wheeled all-terrain vehicles and for infantry field training exercises consisting of land navigation, bivouacking, and temporary construction of fortifications and defensive positions. Training on the property involved the use of smoke grenades, artillery simulators and ground and aerial flares. No live firing was conducted on this range. This property is currently undeveloped, under the control of BLM, and is fenced with locked gates. No UXO removal has taken place at this range.

Administrative Action:

Action ID:	9424
Region:	Not reported
Complete Date:	08/11/2008
Rank Value:	Not reported
Cleanup Flag:	False
Created Date:	08/11/2008
Decode for AgencyID:	Department of Environmental Quality
Decode for RegionID:	Not reported
Category:	Administrative Action
Action Code Flag:	False
Action:	Site added to database
Further Action:	Not reported
Comments:	Not reported

Action ID:	9456
Region:	Eastern Region
Complete Date:	08/04/2009
Rank Value:	Not reported
Cleanup Flag:	False
Created Date:	11/03/2008
Decode for AgencyID:	Other
Decode for RegionID:	Eastern Region
Category:	Remedial Action
Action Code Flag:	False
Action:	BASIC PRELIMINARY ASSESSEMENT
Further Action:	0
Comments:	Not reported

Action ID:	9443
Region:	Eastern Region
Complete Date:	08/04/2009
Rank Value:	Not reported
Cleanup Flag:	False
Created Date:	08/04/2009
Decode for AgencyID:	Department of Environmental Quality
Decode for RegionID:	Eastern Region
Category:	Remedial Action
Action Code Flag:	False
Action:	NO FURTHER STATE ACTION REQUIRED
Further Action:	0
Comments:	Not reported

Operations:

BIAK TRAINING CENTER RANGE 2 (Continued) **S109346110**

Operation Id: 135625
Operation Status: Inactive
Common Name: Biak Training Center Range 1
Yrs of Operation: Not reported
Comments: shooting range
Updated Date: 04/29/2010
Updated By: DCROUSE
Decode for OpstatID: Inactive
Operations SIC Id: 199038
SIC Code: 3482
Created By: DCROUSE
Created Date: 04/29/2010

State ID Number: 5051
Brown ID: 0
Study Area: False
Region ID: 1
Legislatve ID: 0
Investigation: No Further Action
FACA ID: 117731
Further Action: 0
Lat/Long (dms): 44 15 10.10 / -121 6 38.50
County Code: 9.00
Score Value: Not reported
Cerclis ID: Not reported
Township Coord.: 15.00
Township Zone: S
Range Coord: 13.00
Range Zone: E
Section Coord: 25
Qtr Section: Not reported
Tax Lots: Not reported
Size: 115 acres
NPL: False
Orphan: False
Updated By: GWISTAR
Update Date: 10/11/2010
Created Date: 08/11/2008
Decode For RegionID: Eastern Region
Decode For BrownID: Not reported
Decode For Furtheract: Not reported
Decode For Investstat: No Further Action
Decode For Legislative: Not reported

Narrative:
NARR ID: 5751651
NARR Code: Remedial Action
Created By: DANDERS
Created Date: 08/04/2009
Updated By: GWISTAR
Updated Date: 08/14/2009
Decode for NarcdID: Remedial Action
NARR Comments: This range is located to the east of the current installation, on property that was leased from the Bureau of Land Management (BLM) from approximately 1960 through 1980. The Oregon Army National Guard (ORARNG) never owned this land. This range was used by the ORARNG to train troops on tracked and wheeled all terrain vehicles and for infantry field training exercises consisting of land navigation,

BIAK TRAINING CENTER RANGE 2 (Continued) **S109346110**

bivouacking, and temporary construction of fortifications and defensive positions. Training on the property involved the use of smoke grenades, artillery simulators and ground and aerial flares. No live firing was conducted on this range. This property is currently owned by private ranchers and surrounded with fences. No UXO removal has taken place at this range. A Phase I SI included visual and geophysical reconnaissance of the property. The reconnaissance did not identify any risk or hazard at the range and no further action is needed to assure that site is protective of human health and the environment.

NARR ID:	5750959
NARR Code:	1922
Created By:	DANDERS
Created Date:	11/03/2008
Updated By:	DANDERS
Updated Date:	11/03/2008
Decode for NarcdID:	Current Site Summary Statement

NARR Comments: BTC is located in Deschutes and Crook Counties, Oregon and currently consists of approximately 43,985 acres of federal public lands. The installation is approximately three miles southeast of the City of Redmond, Oregon and fourteen miles northeast of the City of Bend, Oregon. During World War II, the U.S. Army conducted training exercises on approximately 31,000 acres of U.S. Bureau of Land Management (BLM) land. BLM has continually issued a special use permit to the Oregon Army National Guard (ORARNG) since the 1960s to allow for military training at BTC. BTC was used as a maneuver area for tracked and wheeled all-terrain vehicles and for infantry field training exercises consisting of land navigation, bivouacking, and temporary construction of fortifications and defensive positions. These same activities still occur throughout the installation. Live fire exercises are not allowed at BTC, except at the small arms range located at the Central Oregon Unit Training Equipment Site (COUTES) within the Operational Range Area. BTC public lands remain open for public use. The primary public uses of BTC are livestock grazing, off-road vehicular recreation, target shooting, rockhounding, hiking, biking, and wildlife viewing. BTC has been referenced under different names in the past. These names include the Central Oregon Training Site, High Desert Training Center, and the Redmond Training Site. ORARNG refers to this installation as Biak Training Center. Two sites (Transferred Range 1 [ECSI #5050] and Transferred Range 2 [ECSI#5051]) were identified as MMRP eligible in previous investigations. Transferred Range 2 is FUDS eligible, but not active Army MMRP eligible. Transferred Range 1 is being addressed under the active Army MMRP process. Transferred Range 2 is a 115.34 acre former range is located to the east of the current installation, on property that was leased from the BLM from approximately 1960 through 1980. The ORARNG never owned this land. This range was used by the ORARNG to train troops on tracked and wheeled all terrain vehicles and for infantry field training exercises consisting of land navigation, bivouacking, and temporary construction of fortifications and defensive positions. Training on the property involved the use of smoke grenades, artillery simulators and ground and aerial flares. No live firing was conducted on this range. This property is currently owned by private parties.

Administrative Action:
Action ID: 9424

BIAK TRAINING CENTER RANGE 2 (Continued) **S109346110**

Region: Not reported
Complete Date: 08/11/2008
Rank Value: Not reported
Cleanup Flag: False
Created Date: 08/11/2008
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Not reported
Category: Administrative Action
Action Code Flag: False
Action: Site added to database
Further Action: Not reported
Comments: Not reported

Action ID: 9456
Region: Eastern Region
Complete Date: 08/04/2009
Rank Value: Not reported
Cleanup Flag: False
Created Date: 11/03/2008
Decode for AgencyID: Other
Decode for RegionID: Eastern Region
Category: Remedial Action
Action Code Flag: False
Action: BASIC PRELIMINARY ASSESSEMENT
Further Action: 0
Comments: Not reported

Action ID: 9443
Region: Eastern Region
Complete Date: 08/04/2009
Rank Value: Not reported
Cleanup Flag: False
Created Date: 08/04/2009
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Remedial Action
Action Code Flag: False
Action: NO FURTHER STATE ACTION REQUIRED
Further Action: 0
Comments: Not reported

Operations:
Operation Id: 135626
Operation Status: Inactive
Common Name: Biak Training Center Range 2
Yrs of Operation: Not reported
Comments: shooting range
Updated Date: 04/29/2010
Updated By: DCROUSE
Decode for OpstatID: Inactive
Operations SIC Id: 199039
SIC Code: 3482
Created By: DCROUSE
Created Date: 04/29/2010

B8	**REDMOND MUNICIPAL AIRPORT - HANGER 10 AREA**	**ECSI**	**S117684800**
WNW	**1020-1050 SE SISTERS AVE**	**VCP**	**N/A**
1/2-1	**REDMOND, OR 97756**		
0.914 mi.			
4824 ft.	**Site 1 of 3 in cluster B**		

Relative:
Lower

Actual:
3064 ft.

ECSI:

State ID Number:	5952
Brown ID:	0
Study Area:	False
Region ID:	1
Legislatve ID:	831
Investigation:	Suspect
FACA ID:	135282
Further Action:	0
Lat/Long (dms):	44 15 34.90 / -121 9 27.70
County Code:	9.00
Score Value:	Not reported
Cerclis ID:	Not reported
Township Coord.:	15.00
Township Zone:	S
Range Coord:	13.00
Range Zone:	E
Section Coord:	22
Qtr Section:	Not reported
Tax Lots:	100
Size:	Not reported
NPL:	False
Orphan:	False
Updated By:	KROBERT
Update Date:	05/12/2015
Created Date:	03/02/2015
Decode For RegionID:	Eastern Region
Decode For BrownID:	Not reported
Decode For Furtheract:	Not reported
Decode For Investstat:	Suspect
Decode For Legislative:	Owner, operator or other party under agreement, order or consent decree under ORS 465.200 or 465.420
Alias Name:	Butler Aircraft Co. - Aerial Firefighting

Narrative:

NARR ID:	5755582
NARR Code:	Remedial Action
Created By:	KROBERT
Created Date:	03/02/2015
Updated By:	KROBERT
Updated Date:	03/02/2015
Decode for NarcdID:	Remedial Action
NARR Comments:	(3/2/15 KJR/VCP) Former aircraft maintenance, pesticide/herbicide storage and handling, ASTs. No known release. Site Investigation is being performed through Deschutes County Brownfield grant.

Administrative Action:

Action ID:	9424
Region:	Not reported
Complete Date:	03/02/2015
Rank Value:	Not reported
Cleanup Flag:	False
Created Date:	03/02/2015
Decode for AgencyID:	Department of Environmental Quality

REDMOND MUNICIPAL AIRPORT - HANGER 10 AREA (Continued) **S117684800**

Decode for RegionID: Not reported
Category: Administrative Action
Action Code Flag: False
Action: Site added to database
Further Action: Not reported
Comments: Not reported

Action ID: 9518
Region: Eastern Region
Complete Date: Not reported
Rank Value: Not reported
Cleanup Flag: False
Created Date: 03/02/2015
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Remedial Action
Action Code Flag: False
Action: TARGETED BROWNFIELD ASSESSMENT
Further Action: 0
Comments: Not reported

Action ID: 9440
Region: Eastern Region
Complete Date: 03/11/2015
Rank Value: Not reported
Cleanup Flag: False
Created Date: 03/11/2015
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Remedial Action
Action Code Flag: False
Action: Letter Agreement
Further Action: 0
Comments: Not reported

VCS:
ECS Site ID: 5952
Facility Size: Not reported
Action: TARGETED BROWNFIELD ASSESSMENT
Start Date: 03/02/2015
End Date: Not reported
Facility Status: Active
Program: VCP
Latitude: 44.2597
Longitude: -121.1577

B9
WNW
1/2-1
0.914 mi.
4824 ft.

REDMOND MUNICIPAL AIRPORT-BUTLER FARM AIR SERVICE **ECSI** **S106980909**
1020 SE SISTERS AVE **N/A**
REDMOND, OR 97756

Site 2 of 3 in cluster B

Relative:
Lower

Actual:
3064 ft.

ECSI:
State ID Number: 4103
Brown ID: 0
Study Area: False
Region ID: 1

REDMOND MUNICIPAL AIRPORT-BUTLER FARM AIR SERVICE (Continued) **S106980909**

Legislatve ID: 0
Investigation: Suspect
FACA ID: 19886
Further Action: 258
Lat/Long (dms): 44 15 35.60 / -121 9 30.20
County Code: 9.00
Score Value: Not reported
Cerclis ID: Not reported
Township Coord.: 15.00
Township Zone: S
Range Coord: 13.00
Range Zone: E
Section Coord: 22
Qtr Section: Not reported
Tax Lots: Not reported
Size: Not reported
NPL: False
Orphan: False
Updated By: KROBERT
Update Date: 05/12/2015
Created Date: 04/15/2004
Decode For RegionID: Eastern Region
Decode For BrownID: Not reported
Decode For Furtheract: Medium
Decode For Investstat: Suspect
Decode For Legislative: Not reported
Alias Name: Butler Aircraft Co.
Alias Name: Butler Aviation
Alias Name: Hanger 130 & Hanger 10

Narrative:
NARR ID: 5744845
NARR Code: Contamination
Created By: DCROUSE
Created Date: 04/15/2004
Updated By: KROBERT
Updated Date: 10/11/2005
Decode for NarcdID: Contamination
NARR Comments: (4/15/04 DMC/SAS) Site added to database for tracking as a long-term aerial applicator. (10/11/05 KJR/SAS) A limited Phase II Site Assessment was performed on 180,000 sq ft of the general aviation ramp located at the Butler Aircraft facility and is used for general airplane storage, maintenance and operations. Nine borings were drilled at the site in June 2005. Bedrock was encountered in all borings at depths between 2.5 feet and about 9.0 feet bgs. Groundwater was not encountered (estimated to be 318 ft to 362 ft bgs). One soil sample was collected and analyzed from each boring for gasoline, diesel, heavy oil, BTEX, organochlorine pesticides, chlorinated herbicides, ammonia-nitrogen, sulfate, phosphate, and glycols. Gasoline, BTEX compounds, pesticides, herbicides, and glycols were not detected. Diesel was detected at levels ranging from 11.9 mg/kg to 15 mg/kg. Heavy oil was detected at levels ranging from 53.1 mg/kg to 410 mg/kg. Concentrations of ammonia-nitrate (0.664 mg/kg, 0.684 mg/kg), phosphorus (394 mg/kg to 734 mg/kg), and sulfate (30.6 mg/kg to 34.2 mg/kg) were detected.

NARR ID: 5744846
NARR Code: Data Sources

REDMOND MUNICIPAL AIRPORT-BUTLER FARM AIR SERVICE (Continued) **S106980909**

Created By: DCROUSE
Created Date: 04/15/2004
Updated By: KROBERT
Updated Date: 10/11/2005
Decode for NarcdID: Data Sources
NARR Comments: 1. Polk City Directories (1950). 2. Butler Aircraft Co. website. 3. Phase II Environmental Site Assessment Report, Kleinfelder, 8/19/05

NARR ID: 5744847
NARR Code: Remedial Action
Created By: DCROUSE
Created Date: 04/15/2004
Updated By: DCROUSE
Updated Date: 11/25/2008
Decode for NarcdID: Remedial Action
NARR Comments: (4/15/04 DMC/SAS) Site screening recommended. (10/11/05 KJR/SAS) Information request sent. Response due 11/18/05. (11/10/05 DMC/SAS) Response from Butler Aircraft received. (1/11/08 KJR/SAS) City of Redmond joined VCP program in July 2006 for DEQ oversight on this and other sites.

Administrative Action:

Action ID: 9495
Region: Eastern Region
Complete Date: 12/31/2013
Rank Value: Not reported
Cleanup Flag: False
Created Date: 12/31/2013
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Remedial Action
Action Code Flag: False
Action: Other recommendation
Further Action: 0
Comments: Not reported

Action ID: 9424
Region: Not reported
Complete Date: 04/15/2004
Rank Value: Not reported
Cleanup Flag: False
Created Date: 04/15/2004
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Not reported
Category: Administrative Action
Action Code Flag: False
Action: Site added to database
Further Action: Not reported
Comments: Not reported

Action ID: 9508
Region: Eastern Region
Complete Date: 04/15/2004
Rank Value: Not reported
Cleanup Flag: False
Created Date: 04/15/2004
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region

REDMOND MUNICIPAL AIRPORT-BUTLER FARM AIR SERVICE (Continued) **S106980909**

Category: Remedial Action
Action Code Flag: False
Action: Site Screening recommended (EV)
Further Action: Medium
Comments: Not reported

Action ID: 9449
Region: Eastern Region
Complete Date: 07/25/2006
Rank Value: Not reported
Cleanup Flag: False
Created Date: 01/11/2008
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Listing Action
Action Code Flag: False
Action: Insufficient information to list
Further Action: 0
Comments: Not reported

Action ID: 9440
Region: Eastern Region
Complete Date: 07/25/2006
Rank Value: Not reported
Cleanup Flag: False
Created Date: 01/11/2008
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Remedial Action
Action Code Flag: False
Action: Letter Agreement
Further Action: 0
Comments: Not reported

Action ID: 9469
Region: Eastern Region
Complete Date: 01/11/2008
Rank Value: Not reported
Cleanup Flag: False
Created Date: 01/11/2008
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Remedial Action
Action Code Flag: False
Action: REMEDIAL ACTION
Further Action: 0
Comments: Not reported

Action ID: 9425
Region: Eastern Region
Complete Date: 07/25/2006
Rank Value: Not reported
Cleanup Flag: False
Created Date: 10/11/2005
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Remedial Action

REDMOND MUNICIPAL AIRPORT-BUTLER FARM AIR SERVICE (Continued) **S106980909**

Action Code Flag: False
Action: SITE EVALUATION
Further Action: 0
Comments: Not reported

Operations:
Operation Id: 134902
Operation Status: Active
Common Name: Butler Farm Air Service
Yrs of Operation: 1946 to present.
Comments: Aerial applicator/crop duster; tankers for fire-fighting.
Updated Date: 12/14/2004
Updated By: DCROUSE
Decode for OpstatID: Active
Operations SIC Id: 198361
SIC Code: 100
Created By: DCROUSE
Created Date: 04/15/2004
Operations SIC Id: 198362
SIC Code: 700
Created By: DCROUSE
Created Date: 04/15/2004
Operations SIC Id: 198363
SIC Code: 4581
Created By: DCROUSE
Created Date: 04/15/2004

10
WNW
1/2-1
0.918 mi.
4847 ft.

MAX MILLS FORMERLY OWNED PROPERTY
HWY 126 (BTWN 27TH & 33RD)
REDMOND, OR 97756

ECSI **S106497209**
VCP **N/A**

Relative:
Lower

Actual:
3053 ft.

ECSI:
State ID Number: 3465
Brown ID: 0
Study Area: False
Region ID: 1
Legislatve ID: 0
Investigation: No Further Action
FACA ID: 46616
Further Action: 0
Lat/Long (dms): 44 15 53.88 / -121 9 11.71
County Code: 9.00
Score Value: 0
Cerclis ID: Not reported
Township Coord.: 15.00
Township Zone: S
Range Coord: 13.00
Range Zone: E
Section Coord: 15
Qtr Section: DCD
Tax Lots: Not reported
Size: Not reported
NPL: False
Orphan: False
Updated By: DCROUSE
Update Date: 01/02/2008

MAX MILLS FORMERLY OWNED PROPERTY (Continued) **S106497209**

Created Date: 09/10/2002
Decode For RegionID: Eastern Region
Decode For BrownID: Not reported
Decode For Furtheract: Not reported
Decode For Investstat: No Further Action
Decode For Legislative: Not reported
Alias Name: Sunset Ridge Development

Narrative:
NARR ID: 5744497
NARR Code: Contamination
Created By: CWALKEY
Created Date: 01/16/2004
Updated By: CWALKEY
Updated Date: 01/16/2004
Decode for NarcdID: Contamination
NARR Comments: (wcw/ICP 1-16-04) diesel (158 mg/Kg); residual levels below risk-based screening of 4,4-DDT and 2,4-D; waste oil.

NARR ID: 5743416
NARR Code: Remedial Action
Created By: DCROUSE
Created Date: 04/24/2003
Updated By: GWISTAR
Updated Date: 01/27/2004
Decode for NarcdID: Remedial Action
NARR Comments: (wcw/ICP 1-16-04) 72.13 tons of petroleum-contaminated soils were excavated and disposed of off-site. NFA recommended, and issued 1-16-03.

Administrative Action:
Action ID: 9443
Region: Eastern Region
Complete Date: 01/09/2003
Rank Value: Not reported
Cleanup Flag: False
Created Date: 04/24/2003
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Remedial Action
Action Code Flag: False
Action: NO FURTHER STATE ACTION REQUIRED
Further Action: 0
Comments: Not reported

Action ID: 9424
Region: Eastern Region
Complete Date: Not reported
Rank Value: 0
Cleanup Flag: False
Created Date: 12/17/2002
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Administrative Action
Action Code Flag: False
Action: Site added to database
Further Action: Not reported
Comments: Not reported

MAX MILLS FORMERLY OWNED PROPERTY (Continued) **S106497209**

Action ID: 9433
Region: Eastern Region
Complete Date: 01/09/2003
Rank Value: 0
Cleanup Flag: True
Created Date: 12/17/2002
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Remedial Action
Action Code Flag: False
Action: INDEPENDENT CLEANUP
Further Action: 0
Comments: Not reported

VCS:
ECS Site ID: 3465
Facility Size: Not reported
Action: NO FURTHER STATE ACTION REQUIRED
Start Date: 12/11/2002
End Date: 01/09/2003
Facility Status: Completed
Program: ICP
Latitude: 44.2649
Longitude: -121.1532

B11 **DESCHUTES READY MIX - REDMOND** **ECSI** **S104550503**
WNW **700 SW SISTERS AVE** **VCP** **N/A**
1/2-1 **REDMOND, OR 97756** **UIC**
0.942 mi.
4973 ft. **Site 3 of 3 in cluster B**

Relative:
Lower

Actual:
3062 ft.

ECSI:
State ID Number: 2637
Brown ID: Not reported
Study Area: False
Region ID: 1
Legislatve ID: Not reported
Investigation: No Further Action
FACA ID: 40954
Further Action: Not reported
Lat/Long (dms): 44 15 44.00 / -121 10 31.00
County Code: 9.00
Score Value: 0
Cerclis ID: Not reported
Township Coord.: 15.00
Township Zone: S
Range Coord: 13.00
Range Zone: E
Section Coord: 21
Qtr Section: Not reported
Tax Lots: Not reported
Size: Not reported
NPL: False
Orphan: False
Updated By: jdk
Update Date: 07/25/2000
Created Date: 07/25/2000

DESCHUTES READY MIX - REDMOND (Continued) **S104550503**

Decode For RegionID:	Eastern Region
Decode For BrownID:	Not reported
Decode For Furtheract:	Not reported
Decode For Investstat:	No Further Action
Decode For Legislative:	Not reported
Alias Name:	Hooker Creek Ranch

Narrative:

NARR ID:	5739895
NARR Code:	Contamination
Created By:	Not reported
Created Date:	12/17/2002
Updated By:	Not reported
Updated Date:	12/17/2002
Decode for NarcdID:	Contamination
NARR Comments:	(7/25/00 JDK/SAS) Consultant called DEQ Bend Office to report release from a 20K-gallon AST on Deschutes Ready Mix site in Redmond. AST no longer on-site. Unclear whether release is historic or from AST removal action.

NARR ID:	5739896
NARR Code:	Hazardous Substance/Waste Types
Created By:	Not reported
Created Date:	12/17/2002
Updated By:	Not reported
Updated Date:	12/17/2002
Decode for NarcdID:	Hazardous Substance/Waste Types
NARR Comments:	Petroleum products

NARR ID:	5739897
NARR Code:	Manner of Release
Created By:	Not reported
Created Date:	12/17/2002
Updated By:	Not reported
Updated Date:	12/17/2002
Decode for NarcdID:	Manner of Release
NARR Comments:	Past business practices; time of release(s) unknown.

NARR ID:	5739898
NARR Code:	Remedial Action
Created By:	Not reported
Created Date:	12/17/2002
Updated By:	Not reported
Updated Date:	12/17/2002
Decode for NarcdID:	Remedial Action
NARR Comments:	(7/25/00 JDK/SAS) Release from 20,000-gallon AST reported to Bend DEQ. AST no longer on-site. Independent Cleanup activities planned or in effect.

Administrative Action:

Action ID:	9443
Region:	Eastern Region
Complete Date:	04/05/2001
Rank Value:	0
Cleanup Flag:	False
Created Date:	12/17/2002
Decode for AgencyID:	Department of Environmental Quality
Decode for RegionID:	Eastern Region

DESCHUTES READY MIX - REDMOND (Continued) **S104550503**

Category: Remedial Action
Action Code Flag: False
Action: NO FURTHER STATE ACTION REQUIRED
Further Action: 0
Comments: Not reported

Action ID: 9435
Region: Eastern Region
Complete Date: 04/05/2001
Rank Value: 0
Cleanup Flag: False
Created Date: 12/17/2002
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Remedial Action
Action Code Flag: False
Action: Independent Cleanup Program
Further Action: Not reported
Comments: Not reported

Action ID: 9424
Region: Eastern Region
Complete Date: Not reported
Rank Value: 0
Cleanup Flag: False
Created Date: 12/17/2002
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Administrative Action
Action Code Flag: False
Action: Site added to database
Further Action: Not reported
Comments: Not reported

Action ID: 9508
Region: Eastern Region
Complete Date: 07/25/2000
Rank Value: 0
Cleanup Flag: False
Created Date: 12/17/2002
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Remedial Action
Action Code Flag: False
Action: Site Screening recommended (EV)
Further Action: Not reported
Comments: Not reported

Action ID: 9440
Region: Eastern Region
Complete Date: 11/30/2000
Rank Value: 0
Cleanup Flag: False
Created Date: 12/17/2002
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Remedial Action

DESCHUTES READY MIX - REDMOND (Continued) **S104550503**

Action Code Flag: False
Action: Letter Agreement
Further Action: Not reported
Comments: Not reported

Action ID: 9425
Region: Eastern Region
Complete Date: 02/15/2001
Rank Value: 0
Cleanup Flag: False
Created Date: 12/17/2002
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Remedial Action
Action Code Flag: False
Action: SITE EVALUATION
Further Action: Not reported
Comments: Not reported

Action ID: 9511
Region: Eastern Region
Complete Date: 02/15/2001
Rank Value: 0
Cleanup Flag: False
Created Date: 12/17/2002
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Remedial Action
Action Code Flag: False
Action: SITE INVESTIGATION
Further Action: Not reported
Comments: Not reported

Action ID: 9437
Region: Eastern Region
Complete Date: 02/15/2001
Rank Value: 0
Cleanup Flag: False
Created Date: 12/17/2002
Decode for AgencyID: Department of Environmental Quality
Decode for RegionID: Eastern Region
Category: Listing Action
Action Code Flag: False
Action: Listing Review completed
Further Action: Not reported
Comments: Not reported

Operations:
Operation Id: 133859
Operation Status: Active
Common Name: Deschutes Ready Mix - Redmond
Yrs of Operation: Not reported
Comments: aphalt plant
Updated Date: 01/05/2002
Updated By: dmc
Decode for OpstatID: Active
Operations SIC Id: 197703
SIC Code: 1442

DESCHUTES READY MIX - REDMOND (Continued) **S104550503**

Created By:	Not reported
Created Date:	12/17/2002
Operations SIC Id:	197704
SIC Code:	2951
Created By:	Not reported
Created Date:	12/17/2002

VCS:

ECS Site ID:	2637
Facility Size:	Not reported
Action:	NO FURTHER STATE ACTION REQUIRED
Start Date:	04/05/2001
End Date:	04/05/2001
Facility Status:	Completed
Program:	ICP
Latitude:	44.2622
Longitude:	-121.1752

OR UIC:

UIC Well #:	1
Type:	5D2
Type Description:	Storm Water Drainage
Status:	Active
UIC Number:	13375
Facility Status:	Not Registered
Lat/Long:	44.2616 / -121.1753

Count: 0 records.

ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
		NO SITES FOUND			

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

To maintain currency of the following federal and state databases, EDR contacts the appropriate governmental agency on a monthly or quarterly basis, as required.

Number of Days to Update: Provides confirmation that EDR is reporting records that have been updated within 90 days from the date the government agency made the information available to the public.

STANDARD ENVIRONMENTAL RECORDS

Federal NPL site list

NPL: National Priority List

National Priorities List (Superfund). The NPL is a subset of CERCLIS and identifies over 1,200 sites for priority cleanup under the Superfund Program. NPL sites may encompass relatively large areas. As such, EDR provides polygon coverage for over 1,000 NPL site boundaries produced by EPA's Environmental Photographic Interpretation Center (EPIC) and regional EPA offices.

Date of Government Version: 07/17/2018
Date Data Arrived at EDR: 08/09/2018
Date Made Active in Reports: 09/07/2018
Number of Days to Update: 29

Source: EPA
Telephone: N/A
Last EDR Contact: 10/04/2018
Next Scheduled EDR Contact: 01/14/2019
Data Release Frequency: Quarterly

NPL Site Boundaries

Sources:

EPA's Environmental Photographic Interpretation Center (EPIC)
Telephone: 202-564-7333

EPA Region 1
Telephone 617-918-1143

EPA Region 3
Telephone 215-814-5418

EPA Region 4
Telephone 404-562-8033

EPA Region 5
Telephone 312-886-6686

EPA Region 10
Telephone 206-553-8665

EPA Region 6
Telephone: 214-655-6659

EPA Region 7
Telephone: 913-551-7247

EPA Region 8
Telephone: 303-312-6774

EPA Region 9
Telephone: 415-947-4246

Proposed NPL: Proposed National Priority List Sites

A site that has been proposed for listing on the National Priorities List through the issuance of a proposed rule in the Federal Register. EPA then accepts public comments on the site, responds to the comments, and places on the NPL those sites that continue to meet the requirements for listing.

Date of Government Version: 07/17/2018
Date Data Arrived at EDR: 08/09/2018
Date Made Active in Reports: 09/07/2018
Number of Days to Update: 29

Source: EPA
Telephone: N/A
Last EDR Contact: 10/04/2018
Next Scheduled EDR Contact: 01/14/2019
Data Release Frequency: Quarterly

NPL LIENS: Federal Superfund Liens

Federal Superfund Liens. Under the authority granted the USEPA by CERCLA of 1980, the USEPA has the authority to file liens against real property in order to recover remedial action expenditures or when the property owner received notification of potential liability. USEPA compiles a listing of filed notices of Superfund Liens.

Date of Government Version: 10/15/1991
Date Data Arrived at EDR: 02/02/1994
Date Made Active in Reports: 03/30/1994
Number of Days to Update: 56

Source: EPA
Telephone: 202-564-4267
Last EDR Contact: 08/15/2011
Next Scheduled EDR Contact: 11/28/2011
Data Release Frequency: No Update Planned

Federal Delisted NPL site list

Delisted NPL: National Priority List Deletions

The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) establishes the criteria that the EPA uses to delete sites from the NPL. In accordance with 40 CFR 300.425.(e), sites may be deleted from the NPL where no further response is appropriate.

Date of Government Version: 07/17/2018
Date Data Arrived at EDR: 08/09/2018
Date Made Active in Reports: 09/07/2018
Number of Days to Update: 29

Source: EPA
Telephone: N/A
Last EDR Contact: 10/04/2018
Next Scheduled EDR Contact: 01/14/2019
Data Release Frequency: Quarterly

Federal CERCLIS list

FEDERAL FACILITY: Federal Facility Site Information listing

A listing of National Priority List (NPL) and Base Realignment and Closure (BRAC) sites found in the Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS) Database where EPA Federal Facilities Restoration and Reuse Office is involved in cleanup activities.

Date of Government Version: 11/07/2016
Date Data Arrived at EDR: 01/05/2017
Date Made Active in Reports: 04/07/2017
Number of Days to Update: 92

Source: Environmental Protection Agency
Telephone: 703-603-8704
Last EDR Contact: 07/06/2018
Next Scheduled EDR Contact: 10/15/2018
Data Release Frequency: Varies

SEMS: Superfund Enterprise Management System

SEMS (Superfund Enterprise Management System) tracks hazardous waste sites, potentially hazardous waste sites, and remedial activities performed in support of EPA’s Superfund Program across the United States. The list was formerly know as CERCLIS, renamed to SEMS by the EPA in 2015. The list contains data on potentially hazardous waste sites that have been reported to the USEPA by states, municipalities, private companies and private persons, pursuant to Section 103 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This dataset also contains sites which are either proposed to or on the National Priorities List (NPL) and the sites which are in the screening and assessment phase for possible inclusion on the NPL.

Date of Government Version: 07/17/2018
Date Data Arrived at EDR: 08/09/2018
Date Made Active in Reports: 09/07/2018
Number of Days to Update: 29

Source: EPA
Telephone: 800-424-9346
Last EDR Contact: 10/04/2018
Next Scheduled EDR Contact: 01/28/2019
Data Release Frequency: Quarterly

Federal CERCLIS NFRAP site list

SEMS-ARCHIVE: Superfund Enterprise Management System Archive

SEMS-ARCHIVE (Superfund Enterprise Management System Archive) tracks sites that have no further interest under the Federal Superfund Program based on available information. The list was formerly known as the CERCLIS-NFRAP, renamed to SEMS ARCHIVE by the EPA in 2015. EPA may perform a minimal level of assessment work at a site while it is archived if site conditions change and/or new information becomes available. Archived sites have been removed and archived from the inventory of SEMS sites. Archived status indicates that, to the best of EPA's knowledge, assessment at a site has been completed and that EPA has determined no further steps will be taken to list the site on the National Priorities List (NPL), unless information indicates this decision was not appropriate or other considerations require a recommendation for listing at a later time. The decision does not necessarily mean that there is no hazard associated with a given site; it only means that. based upon available information, the location is not judged to be potential NPL site.

Date of Government Version: 07/17/2018
Date Data Arrived at EDR: 08/09/2018
Date Made Active in Reports: 09/07/2018
Number of Days to Update: 29

Source: EPA
Telephone: 800-424-9346
Last EDR Contact: 10/04/2018
Next Scheduled EDR Contact: 01/28/2019
Data Release Frequency: Quarterly

Federal RCRA CORRACTS facilities list

CORRACTS: Corrective Action Report
CORRACTS identifies hazardous waste handlers with RCRA corrective action activity.

Date of Government Version: 03/01/2018
Date Data Arrived at EDR: 03/28/2018
Date Made Active in Reports: 06/22/2018
Number of Days to Update: 86

Source: EPA
Telephone: 800-424-9346
Last EDR Contact: 09/19/2018
Next Scheduled EDR Contact: 01/07/2019
Data Release Frequency: Quarterly

Federal RCRA non-CORRACTS TSD facilities list

RCRA-TSDF: RCRA - Treatment, Storage and Disposal
RCRAInfo is EPA's comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. The database includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Transporters are individuals or entities that move hazardous waste from the generator offsite to a facility that can recycle, treat, store, or dispose of the waste. TSDFs treat, store, or dispose of the waste.

Date of Government Version: 03/01/2018
Date Data Arrived at EDR: 03/28/2018
Date Made Active in Reports: 06/22/2018
Number of Days to Update: 86

Source: Environmental Protection Agency
Telephone: (206) 553-1200
Last EDR Contact: 09/19/2018
Next Scheduled EDR Contact: 01/07/2019
Data Release Frequency: Quarterly

Federal RCRA generators list

RCRA-LQG: RCRA - Large Quantity Generators
RCRAInfo is EPA's comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. The database includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Large quantity generators (LQGs) generate over 1,000 kilograms (kg) of hazardous waste, or over 1 kg of acutely hazardous waste per month.

Date of Government Version: 03/01/2018
Date Data Arrived at EDR: 03/28/2018
Date Made Active in Reports: 06/22/2018
Number of Days to Update: 86

Source: Environmental Protection Agency
Telephone: (206) 553-1200
Last EDR Contact: 09/19/2018
Next Scheduled EDR Contact: 01/07/2019
Data Release Frequency: Quarterly

RCRA-SQG: RCRA - Small Quantity Generators

RCRAInfo is EPA's comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. The database includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Small quantity generators (SQGs) generate between 100 kg and 1,000 kg of hazardous waste per month.

Date of Government Version: 03/01/2018	Source: Environmental Protection Agency
Date Data Arrived at EDR: 03/28/2018	Telephone: (206) 553-1200
Date Made Active in Reports: 06/22/2018	Last EDR Contact: 09/19/2018
Number of Days to Update: 86	Next Scheduled EDR Contact: 01/07/2019
	Data Release Frequency: Quarterly

RCRA-CESQG: RCRA - Conditionally Exempt Small Quantity Generators

RCRAInfo is EPA's comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. The database includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Conditionally exempt small quantity generators (CESQGs) generate less than 100 kg of hazardous waste, or less than 1 kg of acutely hazardous waste per month.

Date of Government Version: 03/01/2018	Source: Environmental Protection Agency
Date Data Arrived at EDR: 03/28/2018	Telephone: (206) 553-1200
Date Made Active in Reports: 06/22/2018	Last EDR Contact: 09/19/2018
Number of Days to Update: 86	Next Scheduled EDR Contact: 01/07/2019
	Data Release Frequency: Quarterly

Federal institutional controls / engineering controls registries

LUCIS: Land Use Control Information System

LUCIS contains records of land use control information pertaining to the former Navy Base Realignment and Closure properties.

Date of Government Version: 05/14/2018	Source: Department of the Navy
Date Data Arrived at EDR: 05/18/2018	Telephone: 843-820-7326
Date Made Active in Reports: 07/20/2018	Last EDR Contact: 07/16/2018
Number of Days to Update: 63	Next Scheduled EDR Contact: 11/26/2018
	Data Release Frequency: Varies

US ENG CONTROLS: Engineering Controls Sites List

A listing of sites with engineering controls in place. Engineering controls include various forms of caps, building foundations, liners, and treatment methods to create pathway elimination for regulated substances to enter environmental media or effect human health.

Date of Government Version: 07/31/2018	Source: Environmental Protection Agency
Date Data Arrived at EDR: 08/28/2018	Telephone: 703-603-0695
Date Made Active in Reports: 09/14/2018	Last EDR Contact: 08/28/2018
Number of Days to Update: 17	Next Scheduled EDR Contact: 12/10/2018
	Data Release Frequency: Varies

US INST CONTROL: Sites with Institutional Controls

A listing of sites with institutional controls in place. Institutional controls include administrative measures, such as groundwater use restrictions, construction restrictions, property use restrictions, and post remediation care requirements intended to prevent exposure to contaminants remaining on site. Deed restrictions are generally required as part of the institutional controls.

Date of Government Version: 07/31/2018	Source: Environmental Protection Agency
Date Data Arrived at EDR: 08/28/2018	Telephone: 703-603-0695
Date Made Active in Reports: 09/14/2018	Last EDR Contact: 08/28/2018
Number of Days to Update: 17	Next Scheduled EDR Contact: 12/10/2018
	Data Release Frequency: Varies

Federal ERNS list

ERNS: Emergency Response Notification System

Emergency Response Notification System. ERNS records and stores information on reported releases of oil and hazardous substances.

Date of Government Version: 06/18/2018
Date Data Arrived at EDR: 06/27/2018
Date Made Active in Reports: 09/14/2018
Number of Days to Update: 79

Source: National Response Center, United States Coast Guard
Telephone: 202-267-2180
Last EDR Contact: 09/25/2018
Next Scheduled EDR Contact: 01/07/2019
Data Release Frequency: Quarterly

State- and tribal - equivalent CERCLIS

CRL: Confirmed Release List and Inventory

All facilities with a confirmed release.

Date of Government Version: 08/01/2018
Date Data Arrived at EDR: 08/10/2018
Date Made Active in Reports: 09/24/2018
Number of Days to Update: 45

Source: Department of Environmental Quality
Telephone: 503-229-6170
Last EDR Contact: 08/10/2018
Next Scheduled EDR Contact: 11/26/2018
Data Release Frequency: Quarterly

ECSI: Environmental Cleanup Site Information System

Sites that are or may be contaminated and may require cleanup.

Date of Government Version: 10/01/2018
Date Data Arrived at EDR: 10/03/2018
Date Made Active in Reports: 10/23/2018
Number of Days to Update: 20

Source: Department of Environmental Quality
Telephone: 503-229-6629
Last EDR Contact: 10/03/2018
Next Scheduled EDR Contact: 01/14/2019
Data Release Frequency: Quarterly

State and tribal landfill and/or solid waste disposal site lists

SWF/LF: Solid Waste Facilities List

Solid Waste Facilities/Landfill Sites. SWF/LF type records typically contain an inventory of solid waste disposal facilities or landfills in a particular state. Depending on the state, these may be active or inactive facilities or open dumps that failed to meet RCRA Subtitle D Section 4004 criteria for solid waste landfills or disposal sites.

Date of Government Version: 07/16/2018
Date Data Arrived at EDR: 07/20/2018
Date Made Active in Reports: 08/20/2018
Number of Days to Update: 31

Source: Department of Environmental Quality
Telephone: 503-229-6299
Last EDR Contact: 10/15/2018
Next Scheduled EDR Contact: 01/28/2019
Data Release Frequency: Semi-Annually

State and tribal leaking storage tank lists

LUST: Leaking Underground Storage Tank Database

Leaking Underground Storage Tank Incident Reports. LUST records contain an inventory of reported leaking underground storage tank incidents. Not all states maintain these records, and the information stored varies by state.

Date of Government Version: 07/02/2018
Date Data Arrived at EDR: 08/10/2018
Date Made Active in Reports: 09/24/2018
Number of Days to Update: 45

Source: Department of Environmental Quality
Telephone: 503-229-5790
Last EDR Contact: 08/10/2018
Next Scheduled EDR Contact: 11/26/2018
Data Release Frequency: Quarterly

INDIAN LUST R10: Leaking Underground Storage Tanks on Indian Land

LUSTs on Indian land in Alaska, Idaho, Oregon and Washington.

Date of Government Version: 04/12/2018
Date Data Arrived at EDR: 05/18/2018
Date Made Active in Reports: 07/20/2018
Number of Days to Update: 63

Source: EPA Region 10
Telephone: 206-553-2857
Last EDR Contact: 07/27/2018
Next Scheduled EDR Contact: 11/05/2018
Data Release Frequency: Varies

INDIAN LUST R9: Leaking Underground Storage Tanks on Indian Land
LUSTs on Indian land in Arizona, California, New Mexico and Nevada

Date of Government Version: 04/10/2018
Date Data Arrived at EDR: 05/18/2018
Date Made Active in Reports: 07/20/2018
Number of Days to Update: 63

Source: Environmental Protection Agency
Telephone: 415-972-3372
Last EDR Contact: 07/27/2018
Next Scheduled EDR Contact: 11/05/2018
Data Release Frequency: Varies

INDIAN LUST R8: Leaking Underground Storage Tanks on Indian Land
LUSTs on Indian land in Colorado, Montana, North Dakota, South Dakota, Utah and Wyoming.

Date of Government Version: 04/25/2018
Date Data Arrived at EDR: 05/18/2018
Date Made Active in Reports: 07/20/2018
Number of Days to Update: 63

Source: EPA Region 8
Telephone: 303-312-6271
Last EDR Contact: 07/27/2018
Next Scheduled EDR Contact: 11/05/2018
Data Release Frequency: Varies

INDIAN LUST R6: Leaking Underground Storage Tanks on Indian Land
LUSTs on Indian land in New Mexico and Oklahoma.

Date of Government Version: 04/01/2018
Date Data Arrived at EDR: 05/18/2018
Date Made Active in Reports: 07/20/2018
Number of Days to Update: 63

Source: EPA Region 6
Telephone: 214-665-6597
Last EDR Contact: 07/27/2018
Next Scheduled EDR Contact: 11/05/2018
Data Release Frequency: Varies

INDIAN LUST R4: Leaking Underground Storage Tanks on Indian Land
LUSTs on Indian land in Florida, Mississippi and North Carolina.

Date of Government Version: 05/08/2018
Date Data Arrived at EDR: 05/18/2018
Date Made Active in Reports: 07/20/2018
Number of Days to Update: 63

Source: EPA Region 4
Telephone: 404-562-8677
Last EDR Contact: 07/27/2018
Next Scheduled EDR Contact: 11/05/2018
Data Release Frequency: Varies

INDIAN LUST R1: Leaking Underground Storage Tanks on Indian Land
A listing of leaking underground storage tank locations on Indian Land.

Date of Government Version: 04/13/2018
Date Data Arrived at EDR: 05/18/2018
Date Made Active in Reports: 07/20/2018
Number of Days to Update: 63

Source: EPA Region 1
Telephone: 617-918-1313
Last EDR Contact: 07/27/2018
Next Scheduled EDR Contact: 11/05/2018
Data Release Frequency: Varies

INDIAN LUST R5: Leaking Underground Storage Tanks on Indian Land
Leaking underground storage tanks located on Indian Land in Michigan, Minnesota and Wisconsin.

Date of Government Version: 04/12/2018
Date Data Arrived at EDR: 05/18/2018
Date Made Active in Reports: 07/20/2018
Number of Days to Update: 63

Source: EPA, Region 5
Telephone: 312-886-7439
Last EDR Contact: 07/27/2018
Next Scheduled EDR Contact: 11/05/2018
Data Release Frequency: Varies

INDIAN LUST R7: Leaking Underground Storage Tanks on Indian Land
LUSTs on Indian land in Iowa, Kansas, and Nebraska

Date of Government Version: 04/24/2018	Source: EPA Region 7
Date Data Arrived at EDR: 05/18/2018	Telephone: 913-551-7003
Date Made Active in Reports: 07/20/2018	Last EDR Contact: 07/27/2018
Number of Days to Update: 63	Next Scheduled EDR Contact: 11/05/2018
	Data Release Frequency: Varies

State and tribal registered storage tank lists

FEMA UST: Underground Storage Tank Listing
A listing of all FEMA owned underground storage tanks.

Date of Government Version: 05/15/2017	Source: FEMA
Date Data Arrived at EDR: 05/30/2017	Telephone: 202-646-5797
Date Made Active in Reports: 10/13/2017	Last EDR Contact: 10/10/2018
Number of Days to Update: 136	Next Scheduled EDR Contact: 01/21/2019
	Data Release Frequency: Varies

UST: Underground Storage Tank Database
Registered Underground Storage Tanks. UST’s are regulated under Subtitle I of the Resource Conservation and Recovery Act (RCRA) and must be registered with the state department responsible for administering the UST program. Available information varies by state program.

Date of Government Version: 07/02/2018	Source: Department of Environmental Quality
Date Data Arrived at EDR: 08/10/2018	Telephone: 503-229-5815
Date Made Active in Reports: 09/24/2018	Last EDR Contact: 08/10/2018
Number of Days to Update: 45	Next Scheduled EDR Contact: 11/26/2018
	Data Release Frequency: Quarterly

AST: Aboveground Storage Tanks
Aboveground storage tank locations reported to the Office of State Fire Marshal.

Date of Government Version: 09/05/2017	Source: Office of State Fire Marshal
Date Data Arrived at EDR: 11/16/2017	Telephone: 503-378-3473
Date Made Active in Reports: 01/09/2018	Last EDR Contact: 08/01/2018
Number of Days to Update: 54	Next Scheduled EDR Contact: 11/12/2018
	Data Release Frequency: Semi-Annually

INDIAN UST R4: Underground Storage Tanks on Indian Land
The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 4 (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee and Tribal Nations)

Date of Government Version: 05/08/2018	Source: EPA Region 4
Date Data Arrived at EDR: 05/18/2018	Telephone: 404-562-9424
Date Made Active in Reports: 07/20/2018	Last EDR Contact: 07/27/2018
Number of Days to Update: 63	Next Scheduled EDR Contact: 11/05/2018
	Data Release Frequency: Varies

INDIAN UST R6: Underground Storage Tanks on Indian Land
The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 6 (Louisiana, Arkansas, Oklahoma, New Mexico, Texas and 65 Tribes).

Date of Government Version: 04/01/2018	Source: EPA Region 6
Date Data Arrived at EDR: 05/18/2018	Telephone: 214-665-7591
Date Made Active in Reports: 07/20/2018	Last EDR Contact: 07/27/2018
Number of Days to Update: 63	Next Scheduled EDR Contact: 11/05/2018
	Data Release Frequency: Varies

INDIAN UST R9: Underground Storage Tanks on Indian Land

The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 9 (Arizona, California, Hawaii, Nevada, the Pacific Islands, and Tribal Nations).

Date of Government Version: 04/10/2018	Source: EPA Region 9
Date Data Arrived at EDR: 05/18/2018	Telephone: 415-972-3368
Date Made Active in Reports: 07/20/2018	Last EDR Contact: 07/27/2018
Number of Days to Update: 63	Next Scheduled EDR Contact: 11/05/2018
	Data Release Frequency: Varies

INDIAN UST R5: Underground Storage Tanks on Indian Land

The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 5 (Michigan, Minnesota and Wisconsin and Tribal Nations).

Date of Government Version: 04/12/2018	Source: EPA Region 5
Date Data Arrived at EDR: 05/18/2018	Telephone: 312-886-6136
Date Made Active in Reports: 07/20/2018	Last EDR Contact: 07/27/2018
Number of Days to Update: 63	Next Scheduled EDR Contact: 11/05/2018
	Data Release Frequency: Varies

INDIAN UST R10: Underground Storage Tanks on Indian Land

The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 10 (Alaska, Idaho, Oregon, Washington, and Tribal Nations).

Date of Government Version: 04/12/2018	Source: EPA Region 10
Date Data Arrived at EDR: 05/18/2018	Telephone: 206-553-2857
Date Made Active in Reports: 07/20/2018	Last EDR Contact: 07/27/2018
Number of Days to Update: 63	Next Scheduled EDR Contact: 11/05/2018
	Data Release Frequency: Varies

INDIAN UST R7: Underground Storage Tanks on Indian Land

The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 7 (Iowa, Kansas, Missouri, Nebraska, and 9 Tribal Nations).

Date of Government Version: 04/24/2018	Source: EPA Region 7
Date Data Arrived at EDR: 05/18/2018	Telephone: 913-551-7003
Date Made Active in Reports: 07/20/2018	Last EDR Contact: 07/27/2018
Number of Days to Update: 63	Next Scheduled EDR Contact: 11/05/2018
	Data Release Frequency: Varies

INDIAN UST R1: Underground Storage Tanks on Indian Land

The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 1 (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont and ten Tribal Nations).

Date of Government Version: 04/13/2018	Source: EPA, Region 1
Date Data Arrived at EDR: 05/18/2018	Telephone: 617-918-1313
Date Made Active in Reports: 07/20/2018	Last EDR Contact: 07/27/2018
Number of Days to Update: 63	Next Scheduled EDR Contact: 11/05/2018
	Data Release Frequency: Varies

INDIAN UST R8: Underground Storage Tanks on Indian Land

The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 8 (Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming and 27 Tribal Nations).

Date of Government Version: 04/25/2018	Source: EPA Region 8
Date Data Arrived at EDR: 05/18/2018	Telephone: 303-312-6137
Date Made Active in Reports: 07/20/2018	Last EDR Contact: 07/27/2018
Number of Days to Update: 63	Next Scheduled EDR Contact: 11/05/2018
	Data Release Frequency: Varies

State and tribal institutional control / engineering control registries

ENG CONTROLS: Engineering Controls Recorded at ESCI Sites

Engineering controls are physical measures selected or approved by the Director for the purpose of preventing or minimizing exposure to hazardous substances. Engineering controls may include, but are not limited to, fencing, capping, horizontal or vertical barriers, hydraulic controls, and alternative water supplies.

Date of Government Version: 10/01/2018
Date Data Arrived at EDR: 10/03/2018
Date Made Active in Reports: 10/23/2018
Number of Days to Update: 20

Source: Department of Environmental Quality
Telephone: 503-229-5193
Last EDR Contact: 10/03/2018
Next Scheduled EDR Contact: 01/14/2019
Data Release Frequency: Quarterly

INST CONTROL: Institutional Controls Recorded at ESCI Sites

An institutional control is a legal or administrative tool or action taken to reduce the potential for exposure to hazardous substances. Institutional controls may include, but are not limited to, use restrictions, environmental monitoring requirements, and site access and security measures.

Date of Government Version: 10/01/2018
Date Data Arrived at EDR: 10/03/2018
Date Made Active in Reports: 10/23/2018
Number of Days to Update: 20

Source: Department of Environmental Quality
Telephone: 503-229-5193
Last EDR Contact: 10/03/2018
Next Scheduled EDR Contact: 01/14/2019
Data Release Frequency: Quarterly

State and tribal voluntary cleanup sites

VCS: Voluntary Cleanup Program Sites

Responsible parties have entered into an agreement with DEQ to voluntarily address contamination associated with their property.

Date of Government Version: 06/29/2018
Date Data Arrived at EDR: 07/03/2018
Date Made Active in Reports: 07/23/2018
Number of Days to Update: 20

Source: DEQ
Telephone: 503-229-5256
Last EDR Contact: 10/19/2018
Next Scheduled EDR Contact: 01/14/2019
Data Release Frequency: Quarterly

INDIAN VCP R1: Voluntary Cleanup Priority Listing

A listing of voluntary cleanup priority sites located on Indian Land located in Region 1.

Date of Government Version: 07/27/2015
Date Data Arrived at EDR: 09/29/2015
Date Made Active in Reports: 02/18/2016
Number of Days to Update: 142

Source: EPA, Region 1
Telephone: 617-918-1102
Last EDR Contact: 09/24/2018
Next Scheduled EDR Contact: 01/07/2019
Data Release Frequency: Varies

INDIAN VCP R7: Voluntary Cleanup Priority Lisitng

A listing of voluntary cleanup priority sites located on Indian Land located in Region 7.

Date of Government Version: 03/20/2008
Date Data Arrived at EDR: 04/22/2008
Date Made Active in Reports: 05/19/2008
Number of Days to Update: 27

Source: EPA, Region 7
Telephone: 913-551-7365
Last EDR Contact: 04/20/2009
Next Scheduled EDR Contact: 07/20/2009
Data Release Frequency: Varies

State and tribal Brownfields sites

BROWNFIELDS: Brownfields Projects

Brownfields investigations and/or cleanups that have been conducted in Oregon.

Date of Government Version: 08/01/2018
Date Data Arrived at EDR: 08/10/2018
Date Made Active in Reports: 09/24/2018
Number of Days to Update: 45

Source: Department of Environmental Quality
Telephone: 503-229-6801
Last EDR Contact: 08/10/2018
Next Scheduled EDR Contact: 11/26/2018
Data Release Frequency: Annually

ADDITIONAL ENVIRONMENTAL RECORDS

Local Brownfield lists

US BROWNFIELDS: A Listing of Brownfields Sites

Brownfields are real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant. Cleaning up and reinvesting in these properties takes development pressures off of undeveloped, open land, and both improves and protects the environment. Assessment, Cleanup and Redevelopment Exchange System (ACRES) stores information reported by EPA Brownfields grant recipients on brownfields properties assessed or cleaned up with grant funding as well as information on Targeted Brownfields Assessments performed by EPA Regions. A listing of ACRES Brownfield sites is obtained from Cleanups in My Community. Cleanups in My Community provides information on Brownfields properties for which information is reported back to EPA, as well as areas served by Brownfields grant programs.

Date of Government Version: 06/18/2018
Date Data Arrived at EDR: 06/20/2018
Date Made Active in Reports: 09/14/2018
Number of Days to Update: 86

Source: Environmental Protection Agency
Telephone: 202-566-2777
Last EDR Contact: 09/18/2018
Next Scheduled EDR Contact: 12/31/2018
Data Release Frequency: Semi-Annually

Local Lists of Landfill / Solid Waste Disposal Sites

HIST LF: Old Closed SW Disposal Sites

A list of solid waste disposal sites that have been closed for a long while.

Date of Government Version: 04/01/2000
Date Data Arrived at EDR: 07/08/2003
Date Made Active in Reports: 07/18/2003
Number of Days to Update: 10

Source: Department of Environmental Quality
Telephone: 503-229-5409
Last EDR Contact: 07/08/2003
Next Scheduled EDR Contact: N/A
Data Release Frequency: No Update Planned

SWRCY: Recycling Facility Location Listing

A listing of recycling facility locations.

Date of Government Version: 08/28/2018
Date Data Arrived at EDR: 08/29/2018
Date Made Active in Reports: 09/24/2018
Number of Days to Update: 26

Source: Department of Environmental Quality
Telephone: 503-229-5353
Last EDR Contact: 08/29/2018
Next Scheduled EDR Contact: 12/10/2018
Data Release Frequency: Quarterly

INDIAN ODI: Report on the Status of Open Dumps on Indian Lands

Location of open dumps on Indian land.

Date of Government Version: 12/31/1998
Date Data Arrived at EDR: 12/03/2007
Date Made Active in Reports: 01/24/2008
Number of Days to Update: 52

Source: Environmental Protection Agency
Telephone: 703-308-8245
Last EDR Contact: 07/30/2018
Next Scheduled EDR Contact: 11/12/2018
Data Release Frequency: Varies

ODI: Open Dump Inventory

An open dump is defined as a disposal facility that does not comply with one or more of the Part 257 or Part 258 Subtitle D Criteria.

Date of Government Version: 06/30/1985
Date Data Arrived at EDR: 08/09/2004
Date Made Active in Reports: 09/17/2004
Number of Days to Update: 39

Source: Environmental Protection Agency
Telephone: 800-424-9346
Last EDR Contact: 06/09/2004
Next Scheduled EDR Contact: N/A
Data Release Frequency: No Update Planned

DEBRIS REGION 9: Torres Martinez Reservation Illegal Dump Site Locations

A listing of illegal dump sites location on the Torres Martinez Indian Reservation located in eastern Riverside County and northern Imperial County, California.

Date of Government Version: 01/12/2009
Date Data Arrived at EDR: 05/07/2009
Date Made Active in Reports: 09/21/2009
Number of Days to Update: 137

Source: EPA, Region 9
Telephone: 415-947-4219
Last EDR Contact: 10/22/2018
Next Scheduled EDR Contact: 02/04/2019
Data Release Frequency: No Update Planned

IHS OPEN DUMPS: Open Dumps on Indian Land

A listing of all open dumps located on Indian Land in the United States.

Date of Government Version: 04/01/2014
Date Data Arrived at EDR: 08/06/2014
Date Made Active in Reports: 01/29/2015
Number of Days to Update: 176

Source: Department of Health & Human Serivces, Indian Health Service
Telephone: 301-443-1452
Last EDR Contact: 08/03/2018
Next Scheduled EDR Contact: 11/12/2018
Data Release Frequency: Varies

Local Lists of Hazardous waste / Contaminated Sites

US HIST CDL: National Clandestine Laboratory Register

A listing of clandestine drug lab locations that have been removed from the DEAs National Clandestine Laboratory Register.

Date of Government Version: 05/18/2018
Date Data Arrived at EDR: 06/20/2018
Date Made Active in Reports: 09/14/2018
Number of Days to Update: 86

Source: Drug Enforcement Administration
Telephone: 202-307-1000
Last EDR Contact: 08/28/2018
Next Scheduled EDR Contact: 12/10/2018
Data Release Frequency: No Update Planned

AOC COL: Columbia Slough

Columbia Slough waterway boundaries.

Date of Government Version: 08/10/2005
Date Data Arrived at EDR: 05/17/2006
Date Made Active in Reports: 06/16/2006
Number of Days to Update: 30

Source: City of Portland Environmental Services
Telephone: 503-823-5310
Last EDR Contact: 03/13/2007
Next Scheduled EDR Contact: N/A
Data Release Frequency: No Update Planned

AOC MU: East Multnomah County Area

Approximate extent of TSA VOC plume February , 2002

Date of Government Version: N/A
Date Data Arrived at EDR: 10/07/2002
Date Made Active in Reports: 10/22/2002
Number of Days to Update: 15

Source: City of Portland Environmental Services
Telephone: 503-823-5310
Last EDR Contact: 03/13/2007
Next Scheduled EDR Contact: N/A
Data Release Frequency: No Update Planned

CDL 2: Clandestine Drug Lab Site Listing

A listing of clandestine drug lab site locations included in the Incident database.

Date of Government Version: 07/01/2018
Date Data Arrived at EDR: 08/01/2018
Date Made Active in Reports: 08/15/2018
Number of Days to Update: 14

Source: Oregon State Police
Telephone: 503-373-1540
Last EDR Contact: 08/01/2018
Next Scheduled EDR Contact: 11/12/2018
Data Release Frequency: Varies

CDL: Uninhabitable Drug Lab Properties

The properties listed on these county pages have been declared by a law enforcement agency to be unfit for use due to meth lab and/or storage activities. The properties are considered uninhabitable until cleaned up by a state certified decontamination contractor and a certificate of fitness is issued by the Oregon Health Division.

Date of Government Version: 09/21/2018
Date Data Arrived at EDR: 09/25/2018
Date Made Active in Reports: 10/22/2018
Number of Days to Update: 27

Source: Department of Consumer & Business Services
Telephone: 503-378-4133
Last EDR Contact: 08/01/2018
Next Scheduled EDR Contact: 11/19/2018
Data Release Frequency: Quarterly

US CDL: Clandestine Drug Labs

A listing of clandestine drug lab locations. The U.S. Department of Justice ("the Department") provides this web site as a public service. It contains addresses of some locations where law enforcement agencies reported they found chemicals or other items that indicated the presence of either clandestine drug laboratories or dumpsites. In most cases, the source of the entries is not the Department, and the Department has not verified the entry and does not guarantee its accuracy. Members of the public must verify the accuracy of all entries by, for example, contacting local law enforcement and local health departments.

Date of Government Version: 05/18/2018
Date Data Arrived at EDR: 06/20/2018
Date Made Active in Reports: 09/14/2018
Number of Days to Update: 86

Source: Drug Enforcement Administration
Telephone: 202-307-1000
Last EDR Contact: 08/28/2018
Next Scheduled EDR Contact: 12/10/2018
Data Release Frequency: Quarterly

Local Land Records

LIENS 2: CERCLA Lien Information

A Federal CERCLA ('Superfund') lien can exist by operation of law at any site or property at which EPA has spent Superfund monies. These monies are spent to investigate and address releases and threatened releases of contamination. CERCLIS provides information as to the identity of these sites and properties.

Date of Government Version: 07/17/2018
Date Data Arrived at EDR: 08/09/2018
Date Made Active in Reports: 10/05/2018
Number of Days to Update: 57

Source: Environmental Protection Agency
Telephone: 202-564-6023
Last EDR Contact: 10/04/2018
Next Scheduled EDR Contact: 01/14/2019
Data Release Frequency: Semi-Annually

Records of Emergency Release Reports

HMIRS: Hazardous Materials Information Reporting System

Hazardous Materials Incident Report System. HMIRS contains hazardous material spill incidents reported to DOT.

Date of Government Version: 03/26/2018
Date Data Arrived at EDR: 03/27/2018
Date Made Active in Reports: 06/08/2018
Number of Days to Update: 73

Source: U.S. Department of Transportation
Telephone: 202-366-4555
Last EDR Contact: 09/25/2018
Next Scheduled EDR Contact: 01/07/2019
Data Release Frequency: Quarterly

SPILLS: Spill Data

Oil and hazardous material spills reported to the Environmental Response Program.

Date of Government Version: 10/01/2018
Date Data Arrived at EDR: 10/02/2018
Date Made Active in Reports: 10/23/2018
Number of Days to Update: 21

Source: Department of Environmental Quality
Telephone: 503-229-5815
Last EDR Contact: 10/01/2018
Next Scheduled EDR Contact: 01/14/2019
Data Release Frequency: Semi-Annually

HAZMAT: Hazmat/Incidents

Hazardous material incidents reported to the State Fire Marshal by emergency responders. The hazardous material may or may not have been released.

Date of Government Version: 07/01/2018
Date Data Arrived at EDR: 08/01/2018
Date Made Active in Reports: 08/15/2018
Number of Days to Update: 14

Source: State Fire Marshal's Office
Telephone: 503-373-1540
Last EDR Contact: 08/01/2018
Next Scheduled EDR Contact: 11/12/2018
Data Release Frequency: Semi-Annually

SPILLS 90: SPILLS90 data from FirstSearch

Spills 90 includes those spill and release records available exclusively from FirstSearch databases. Typically, they may include chemical, oil and/or hazardous substance spills recorded after 1990. Duplicate records that are already included in EDR incident and release records are not included in Spills 90.

Date of Government Version: 05/01/2006	Source: FirstSearch
Date Data Arrived at EDR: 01/03/2013	Telephone: N/A
Date Made Active in Reports: 02/22/2013	Last EDR Contact: 01/03/2013
Number of Days to Update: 50	Next Scheduled EDR Contact: N/A
	Data Release Frequency: No Update Planned

Other Ascertainable Records

RCRA NonGen / NLR: RCRA - Non Generators / No Longer Regulated

RCRAInfo is EPA's comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. The database includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Non-Generators do not presently generate hazardous waste.

Date of Government Version: 03/01/2018	Source: Environmental Protection Agency
Date Data Arrived at EDR: 03/28/2018	Telephone: (206) 553-1200
Date Made Active in Reports: 06/22/2018	Last EDR Contact: 09/19/2018
Number of Days to Update: 86	Next Scheduled EDR Contact: 01/07/2019
	Data Release Frequency: Quarterly

FUDS: Formerly Used Defense Sites

The listing includes locations of Formerly Used Defense Sites properties where the US Army Corps of Engineers is actively working or will take necessary cleanup actions.

Date of Government Version: 01/31/2015	Source: U.S. Army Corps of Engineers
Date Data Arrived at EDR: 07/08/2015	Telephone: 202-528-4285
Date Made Active in Reports: 10/13/2015	Last EDR Contact: 08/24/2018
Number of Days to Update: 97	Next Scheduled EDR Contact: 12/03/2018
	Data Release Frequency: Varies

DOD: Department of Defense Sites

This data set consists of federally owned or administered lands, administered by the Department of Defense, that have any area equal to or greater than 640 acres of the United States, Puerto Rico, and the U.S. Virgin Islands.

Date of Government Version: 12/31/2005	Source: USGS
Date Data Arrived at EDR: 11/10/2006	Telephone: 888-275-8747
Date Made Active in Reports: 01/11/2007	Last EDR Contact: 10/12/2018
Number of Days to Update: 62	Next Scheduled EDR Contact: 01/21/2019
	Data Release Frequency: Semi-Annually

FEDLAND: Federal and Indian Lands

Federally and Indian administrated lands of the United States. Lands included are administrated by: Army Corps of Engineers, Bureau of Reclamation, National Wild and Scenic River, National Wildlife Refuge, Public Domain Land, Wilderness, Wilderness Study Area, Wildlife Management Area, Bureau of Indian Affairs, Bureau of Land Management, Department of Justice, Forest Service, Fish and Wildlife Service, National Park Service.

Date of Government Version: 12/31/2005	Source: U.S. Geological Survey
Date Data Arrived at EDR: 02/06/2006	Telephone: 888-275-8747
Date Made Active in Reports: 01/11/2007	Last EDR Contact: 10/12/2018
Number of Days to Update: 339	Next Scheduled EDR Contact: 01/21/2019
	Data Release Frequency: N/A

SCRD DRYCLEANERS: State Coalition for Remediation of Drycleaners Listing

The State Coalition for Remediation of Drycleaners was established in 1998, with support from the U.S. EPA Office of Superfund Remediation and Technology Innovation. It is comprised of representatives of states with established drycleaner remediation programs. Currently the member states are Alabama, Connecticut, Florida, Illinois, Kansas, Minnesota, Missouri, North Carolina, Oregon, South Carolina, Tennessee, Texas, and Wisconsin.

Date of Government Version: 01/01/2017
Date Data Arrived at EDR: 02/03/2017
Date Made Active in Reports: 04/07/2017
Number of Days to Update: 63

Source: Environmental Protection Agency
Telephone: 615-532-8599
Last EDR Contact: 08/17/2018
Next Scheduled EDR Contact: 11/26/2018
Data Release Frequency: Varies

US FIN ASSUR: Financial Assurance Information

All owners and operators of facilities that treat, store, or dispose of hazardous waste are required to provide proof that they will have sufficient funds to pay for the clean up, closure, and post-closure care of their facilities.

Date of Government Version: 05/31/2018
Date Data Arrived at EDR: 06/27/2018
Date Made Active in Reports: 10/05/2018
Number of Days to Update: 100

Source: Environmental Protection Agency
Telephone: 202-566-1917
Last EDR Contact: 09/25/2018
Next Scheduled EDR Contact: 01/07/2019
Data Release Frequency: Quarterly

EPA WATCH LIST: EPA WATCH LIST

EPA maintains a "Watch List" to facilitate dialogue between EPA, state and local environmental agencies on enforcement matters relating to facilities with alleged violations identified as either significant or high priority. Being on the Watch List does not mean that the facility has actually violated the law only that an investigation by EPA or a state or local environmental agency has led those organizations to allege that an unproven violation has in fact occurred. Being on the Watch List does not represent a higher level of concern regarding the alleged violations that were detected, but instead indicates cases requiring additional dialogue between EPA, state and local agencies - primarily because of the length of time the alleged violation has gone unaddressed or unresolved.

Date of Government Version: 08/30/2013
Date Data Arrived at EDR: 03/21/2014
Date Made Active in Reports: 06/17/2014
Number of Days to Update: 88

Source: Environmental Protection Agency
Telephone: 617-520-3000
Last EDR Contact: 08/03/2018
Next Scheduled EDR Contact: 11/19/2018
Data Release Frequency: Quarterly

2020 COR ACTION: 2020 Corrective Action Program List

The EPA has set ambitious goals for the RCRA Corrective Action program by creating the 2020 Corrective Action Universe. This RCRA cleanup baseline includes facilities expected to need corrective action. The 2020 universe contains a wide variety of sites. Some properties are heavily contaminated while others were contaminated but have since been cleaned up. Still others have not been fully investigated yet, and may require little or no remediation. Inclusion in the 2020 Universe does not necessarily imply failure on the part of a facility to meet its RCRA obligations.

Date of Government Version: 09/30/2017
Date Data Arrived at EDR: 05/08/2018
Date Made Active in Reports: 07/20/2018
Number of Days to Update: 73

Source: Environmental Protection Agency
Telephone: 703-308-4044
Last EDR Contact: 08/10/2018
Next Scheduled EDR Contact: 11/19/2018
Data Release Frequency: Varies

TSCA: Toxic Substances Control Act

Toxic Substances Control Act. TSCA identifies manufacturers and importers of chemical substances included on the TSCA Chemical Substance Inventory list. It includes data on the production volume of these substances by plant site.

Date of Government Version: 12/31/2016
Date Data Arrived at EDR: 06/21/2017
Date Made Active in Reports: 01/05/2018
Number of Days to Update: 198

Source: EPA
Telephone: 202-260-5521
Last EDR Contact: 09/21/2018
Next Scheduled EDR Contact: 12/31/2018
Data Release Frequency: Every 4 Years

TRIS: Toxic Chemical Release Inventory System

Toxic Release Inventory System. TRIS identifies facilities which release toxic chemicals to the air, water and land in reportable quantities under SARA Title III Section 313.

Date of Government Version: 12/31/2016
Date Data Arrived at EDR: 01/10/2018
Date Made Active in Reports: 01/12/2018
Number of Days to Update: 2

Source: EPA
Telephone: 202-566-0250
Last EDR Contact: 08/24/2018
Next Scheduled EDR Contact: 12/03/2018
Data Release Frequency: Annually

SSTS: Section 7 Tracking Systems

Section 7 of the Federal Insecticide, Fungicide and Rodenticide Act, as amended (92 Stat. 829) requires all registered pesticide-producing establishments to submit a report to the Environmental Protection Agency by March 1st each year. Each establishment must report the types and amounts of pesticides, active ingredients and devices being produced, and those having been produced and sold or distributed in the past year.

Date of Government Version: 12/31/2009
Date Data Arrived at EDR: 12/10/2010
Date Made Active in Reports: 02/25/2011
Number of Days to Update: 77

Source: EPA
Telephone: 202-564-4203
Last EDR Contact: 10/24/2018
Next Scheduled EDR Contact: 02/04/2019
Data Release Frequency: Annually

ROD: Records Of Decision

Record of Decision. ROD documents mandate a permanent remedy at an NPL (Superfund) site containing technical and health information to aid in the cleanup.

Date of Government Version: 07/17/2018
Date Data Arrived at EDR: 08/09/2018
Date Made Active in Reports: 10/05/2018
Number of Days to Update: 57

Source: EPA
Telephone: 703-416-0223
Last EDR Contact: 10/04/2018
Next Scheduled EDR Contact: 12/17/2018
Data Release Frequency: Annually

RMP: Risk Management Plans

When Congress passed the Clean Air Act Amendments of 1990, it required EPA to publish regulations and guidance for chemical accident prevention at facilities using extremely hazardous substances. The Risk Management Program Rule (RMP Rule) was written to implement Section 112(r) of these amendments. The rule, which built upon existing industry codes and standards, requires companies of all sizes that use certain flammable and toxic substances to develop a Risk Management Program, which includes a(n): Hazard assessment that details the potential effects of an accidental release, an accident history of the last five years, and an evaluation of worst-case and alternative accidental releases; Prevention program that includes safety precautions and maintenance, monitoring, and employee training measures; and Emergency response program that spells out emergency health care, employee training measures and procedures for informing the public and response agencies (e.g the fire department) should an accident occur.

Date of Government Version: 08/01/2018
Date Data Arrived at EDR: 08/22/2018
Date Made Active in Reports: 10/05/2018
Number of Days to Update: 44

Source: Environmental Protection Agency
Telephone: 202-564-8600
Last EDR Contact: 10/23/2018
Next Scheduled EDR Contact: 02/04/2019
Data Release Frequency: Varies

RAATS: RCRA Administrative Action Tracking System

RCRA Administration Action Tracking System. RAATS contains records based on enforcement actions issued under RCRA pertaining to major violators and includes administrative and civil actions brought by the EPA. For administration actions after September 30, 1995, data entry in the RAATS database was discontinued. EPA will retain a copy of the database for historical records. It was necessary to terminate RAATS because a decrease in agency resources made it impossible to continue to update the information contained in the database.

Date of Government Version: 04/17/1995
Date Data Arrived at EDR: 07/03/1995
Date Made Active in Reports: 08/07/1995
Number of Days to Update: 35

Source: EPA
Telephone: 202-564-4104
Last EDR Contact: 06/02/2008
Next Scheduled EDR Contact: 09/01/2008
Data Release Frequency: No Update Planned

PRP: Potentially Responsible Parties
A listing of verified Potentially Responsible Parties

Date of Government Version: 10/25/2013
Date Data Arrived at EDR: 10/17/2014
Date Made Active in Reports: 10/20/2014
Number of Days to Update: 3

Source: EPA
Telephone: 202-564-6023
Last EDR Contact: 10/04/2018
Next Scheduled EDR Contact: 11/19/2018
Data Release Frequency: Quarterly

PADS: PCB Activity Database System
PCB Activity Database. PADS Identifies generators, transporters, commercial storers and/or brokers and disposers of PCB's who are required to notify the EPA of such activities.

Date of Government Version: 06/01/2017
Date Data Arrived at EDR: 06/09/2017
Date Made Active in Reports: 10/13/2017
Number of Days to Update: 126

Source: EPA
Telephone: 202-566-0500
Last EDR Contact: 10/11/2018
Next Scheduled EDR Contact: 01/21/2019
Data Release Frequency: Annually

ICIS: Integrated Compliance Information System
The Integrated Compliance Information System (ICIS) supports the information needs of the national enforcement and compliance program as well as the unique needs of the National Pollutant Discharge Elimination System (NPDES) program.

Date of Government Version: 11/18/2016
Date Data Arrived at EDR: 11/23/2016
Date Made Active in Reports: 02/10/2017
Number of Days to Update: 79

Source: Environmental Protection Agency
Telephone: 202-564-2501
Last EDR Contact: 10/09/2018
Next Scheduled EDR Contact: 01/21/2019
Data Release Frequency: Quarterly

FTTS: FIFRA/ TSCA Tracking System - FIFRA (Federal Insecticide, Fungicide, & Rodenticide Act)/TSCA (Toxic Substances Control Act)
FTTS tracks administrative cases and pesticide enforcement actions and compliance activities related to FIFRA, TSCA and EPCRA (Emergency Planning and Community Right-to-Know Act). To maintain currency, EDR contacts the Agency on a quarterly basis.

Date of Government Version: 04/09/2009
Date Data Arrived at EDR: 04/16/2009
Date Made Active in Reports: 05/11/2009
Number of Days to Update: 25

Source: EPA/Office of Prevention, Pesticides and Toxic Substances
Telephone: 202-566-1667
Last EDR Contact: 08/18/2017
Next Scheduled EDR Contact: 12/04/2017
Data Release Frequency: Quarterly

FTTS INSP: FIFRA/ TSCA Tracking System - FIFRA (Federal Insecticide, Fungicide, & Rodenticide Act)/TSCA (Toxic Substances Control Act)
A listing of FIFRA/TSCA Tracking System (FTTS) inspections and enforcements.

Date of Government Version: 04/09/2009
Date Data Arrived at EDR: 04/16/2009
Date Made Active in Reports: 05/11/2009
Number of Days to Update: 25

Source: EPA
Telephone: 202-566-1667
Last EDR Contact: 08/18/2017
Next Scheduled EDR Contact: 12/04/2017
Data Release Frequency: Quarterly

MLTS: Material Licensing Tracking System
MLTS is maintained by the Nuclear Regulatory Commission and contains a list of approximately 8,100 sites which possess or use radioactive materials and which are subject to NRC licensing requirements. To maintain currency, EDR contacts the Agency on a quarterly basis.

Date of Government Version: 08/30/2016
Date Data Arrived at EDR: 09/08/2016
Date Made Active in Reports: 10/21/2016
Number of Days to Update: 43

Source: Nuclear Regulatory Commission
Telephone: 301-415-7169
Last EDR Contact: 09/28/2018
Next Scheduled EDR Contact: 11/05/2018
Data Release Frequency: Quarterly

COAL ASH DOE: Steam-Electric Plant Operation Data

A listing of power plants that store ash in surface ponds.

Date of Government Version: 12/31/2005
Date Data Arrived at EDR: 08/07/2009
Date Made Active in Reports: 10/22/2009
Number of Days to Update: 76

Source: Department of Energy
Telephone: 202-586-8719
Last EDR Contact: 09/07/2018
Next Scheduled EDR Contact: 12/17/2018
Data Release Frequency: Varies

COAL ASH EPA: Coal Combustion Residues Surface Impoundments List

A listing of coal combustion residues surface impoundments with high hazard potential ratings.

Date of Government Version: 07/01/2014
Date Data Arrived at EDR: 09/10/2014
Date Made Active in Reports: 10/20/2014
Number of Days to Update: 40

Source: Environmental Protection Agency
Telephone: N/A
Last EDR Contact: 09/04/2018
Next Scheduled EDR Contact: 12/17/2018
Data Release Frequency: Varies

PCB TRANSFORMER: PCB Transformer Registration Database

The database of PCB transformer registrations that includes all PCB registration submittals.

Date of Government Version: 05/24/2017
Date Data Arrived at EDR: 11/30/2017
Date Made Active in Reports: 12/15/2017
Number of Days to Update: 15

Source: Environmental Protection Agency
Telephone: 202-566-0517
Last EDR Contact: 07/27/2018
Next Scheduled EDR Contact: 11/05/2018
Data Release Frequency: Varies

RADINFO: Radiation Information Database

The Radiation Information Database (RADINFO) contains information about facilities that are regulated by U.S. Environmental Protection Agency (EPA) regulations for radiation and radioactivity.

Date of Government Version: 07/02/2018
Date Data Arrived at EDR: 07/05/2018
Date Made Active in Reports: 10/05/2018
Number of Days to Update: 92

Source: Environmental Protection Agency
Telephone: 202-343-9775
Last EDR Contact: 10/03/2018
Next Scheduled EDR Contact: 01/14/2019
Data Release Frequency: Quarterly

HIST FTTS: FIFRA/TSCA Tracking System Administrative Case Listing

A complete administrative case listing from the FIFRA/TSCA Tracking System (FTTS) for all ten EPA regions. The information was obtained from the National Compliance Database (NCDB). NCDB supports the implementation of FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act) and TSCA (Toxic Substances Control Act). Some EPA regions are now closing out records. Because of that, and the fact that some EPA regions are not providing EPA Headquarters with updated records, it was decided to create a HIST FTTS database. It included records that may not be included in the newer FTTS database updates. This database is no longer updated.

Date of Government Version: 10/19/2006
Date Data Arrived at EDR: 03/01/2007
Date Made Active in Reports: 04/10/2007
Number of Days to Update: 40

Source: Environmental Protection Agency
Telephone: 202-564-2501
Last EDR Contact: 12/17/2007
Next Scheduled EDR Contact: 03/17/2008
Data Release Frequency: No Update Planned

HIST FTTS INSP: FIFRA/TSCA Tracking System Inspection & Enforcement Case Listing

A complete inspection and enforcement case listing from the FIFRA/TSCA Tracking System (FTTS) for all ten EPA regions. The information was obtained from the National Compliance Database (NCDB). NCDB supports the implementation of FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act) and TSCA (Toxic Substances Control Act). Some EPA regions are now closing out records. Because of that, and the fact that some EPA regions are not providing EPA Headquarters with updated records, it was decided to create a HIST FTTS database. It included records that may not be included in the newer FTTS database updates. This database is no longer updated.

Date of Government Version: 10/19/2006
Date Data Arrived at EDR: 03/01/2007
Date Made Active in Reports: 04/10/2007
Number of Days to Update: 40

Source: Environmental Protection Agency
Telephone: 202-564-2501
Last EDR Contact: 12/17/2008
Next Scheduled EDR Contact: 03/17/2008
Data Release Frequency: No Update Planned

DOT OPS: Incident and Accident Data

Department of Transporation, Office of Pipeline Safety Incident and Accident data.

Date of Government Version: 07/31/2012
Date Data Arrived at EDR: 08/07/2012
Date Made Active in Reports: 09/18/2012
Number of Days to Update: 42

Source: Department of Transporation, Office of Pipeline Safety
Telephone: 202-366-4595
Last EDR Contact: 08/09/2018
Next Scheduled EDR Contact: 11/12/2018
Data Release Frequency: Varies

CONSENT: Superfund (CERCLA) Consent Decrees

Major legal settlements that establish responsibility and standards for cleanup at NPL (Superfund) sites. Released periodically by United States District Courts after settlement by parties to litigation matters.

Date of Government Version: 06/30/2018
Date Data Arrived at EDR: 07/17/2018
Date Made Active in Reports: 10/05/2018
Number of Days to Update: 80

Source: Department of Justice, Consent Decree Library
Telephone: Varies
Last EDR Contact: 10/01/2018
Next Scheduled EDR Contact: 12/31/2018
Data Release Frequency: Varies

BRS: Biennial Reporting System

The Biennial Reporting System is a national system administered by the EPA that collects data on the generation and management of hazardous waste. BRS captures detailed data from two groups: Large Quantity Generators (LQG) and Treatment, Storage, and Disposal Facilities.

Date of Government Version: 12/31/2015
Date Data Arrived at EDR: 02/22/2017
Date Made Active in Reports: 09/28/2017
Number of Days to Update: 218

Source: EPA/NTIS
Telephone: 800-424-9346
Last EDR Contact: 08/24/2018
Next Scheduled EDR Contact: 12/03/2018
Data Release Frequency: Biennially

INDIAN RESERV: Indian Reservations

This map layer portrays Indian administered lands of the United States that have any area equal to or greater than 640 acres.

Date of Government Version: 12/31/2014
Date Data Arrived at EDR: 07/14/2015
Date Made Active in Reports: 01/10/2017
Number of Days to Update: 546

Source: USGS
Telephone: 202-208-3710
Last EDR Contact: 10/09/2018
Next Scheduled EDR Contact: 01/21/2019
Data Release Frequency: Semi-Annually

FUSRAP: Formerly Utilized Sites Remedial Action Program

DOE established the Formerly Utilized Sites Remedial Action Program (FUSRAP) in 1974 to remediate sites where radioactive contamination remained from Manhattan Project and early U.S. Atomic Energy Commission (AEC) operations.

Date of Government Version: 08/08/2017
Date Data Arrived at EDR: 09/11/2018
Date Made Active in Reports: 09/14/2018
Number of Days to Update: 3

Source: Department of Energy
Telephone: 202-586-3559
Last EDR Contact: 09/11/2018
Next Scheduled EDR Contact: 11/19/2018
Data Release Frequency: Varies

UMTRA: Uranium Mill Tailings Sites

Uranium ore was mined by private companies for federal government use in national defense programs. When the mills shut down, large piles of the sand-like material (mill tailings) remain after uranium has been extracted from the ore. Levels of human exposure to radioactive materials from the piles are low; however, in some cases tailings were used as construction materials before the potential health hazards of the tailings were recognized.

Date of Government Version: 06/23/2017
Date Data Arrived at EDR: 10/11/2017
Date Made Active in Reports: 11/03/2017
Number of Days to Update: 23

Source: Department of Energy
Telephone: 505-845-0011
Last EDR Contact: 08/20/2018
Next Scheduled EDR Contact: 12/03/2018
Data Release Frequency: Varies

LEAD SMELTER 1: Lead Smelter Sites

A listing of former lead smelter site locations.

Date of Government Version: 07/17/2018
Date Data Arrived at EDR: 08/09/2018
Date Made Active in Reports: 10/05/2018
Number of Days to Update: 57

Source: Environmental Protection Agency
Telephone: 703-603-8787
Last EDR Contact: 10/04/2018
Next Scheduled EDR Contact: 01/14/2019
Data Release Frequency: Varies

LEAD SMELTER 2: Lead Smelter Sites

A list of several hundred sites in the U.S. where secondary lead smelting was done from 1931and 1964. These sites may pose a threat to public health through ingestion or inhalation of contaminated soil or dust

Date of Government Version: 04/05/2001
Date Data Arrived at EDR: 10/27/2010
Date Made Active in Reports: 12/02/2010
Number of Days to Update: 36

Source: American Journal of Public Health
Telephone: 703-305-6451
Last EDR Contact: 12/02/2009
Next Scheduled EDR Contact: N/A
Data Release Frequency: No Update Planned

US AIRS (AFS): Aerometric Information Retrieval System Facility Subsystem (AFS)

The database is a sub-system of Aerometric Information Retrieval System (AIRS). AFS contains compliance data on air pollution point sources regulated by the U.S. EPA and/or state and local air regulatory agencies. This information comes from source reports by various stationary sources of air pollution, such as electric power plants, steel mills, factories, and universities, and provides information about the air pollutants they produce. Action, air program, air program pollutant, and general level plant data. It is used to track emissions and compliance data from industrial plants.

Date of Government Version: 10/12/2016
Date Data Arrived at EDR: 10/26/2016
Date Made Active in Reports: 02/03/2017
Number of Days to Update: 100

Source: EPA
Telephone: 202-564-2496
Last EDR Contact: 09/26/2017
Next Scheduled EDR Contact: 01/08/2018
Data Release Frequency: Annually

US AIRS MINOR: Air Facility System Data

A listing of minor source facilities.

Date of Government Version: 10/12/2016
Date Data Arrived at EDR: 10/26/2016
Date Made Active in Reports: 02/03/2017
Number of Days to Update: 100

Source: EPA
Telephone: 202-564-2496
Last EDR Contact: 09/26/2017
Next Scheduled EDR Contact: 01/08/2018
Data Release Frequency: Annually

US MINES: Mines Master Index File

Contains all mine identification numbers issued for mines active or opened since 1971. The data also includes violation information.

Date of Government Version: 08/01/2018
Date Data Arrived at EDR: 08/29/2018
Date Made Active in Reports: 10/05/2018
Number of Days to Update: 37

Source: Department of Labor, Mine Safety and Health Administration
Telephone: 303-231-5959
Last EDR Contact: 08/29/2018
Next Scheduled EDR Contact: 12/10/2018
Data Release Frequency: Semi-Annually

US MINES 2: Ferrous and Nonferrous Metal Mines Database Listing

This map layer includes ferrous (ferrous metal mines are facilities that extract ferrous metals, such as iron ore or molybdenum) and nonferrous (Nonferrous metal mines are facilities that extract nonferrous metals, such as gold, silver, copper, zinc, and lead) metal mines in the United States.

Date of Government Version: 12/05/2005
Date Data Arrived at EDR: 02/29/2008
Date Made Active in Reports: 04/18/2008
Number of Days to Update: 49

Source: USGS
Telephone: 703-648-7709
Last EDR Contact: 08/31/2018
Next Scheduled EDR Contact: 12/10/2018
Data Release Frequency: Varies

US MINES 3: Active Mines & Mineral Plants Database Listing

Active Mines and Mineral Processing Plant operations for commodities monitored by the Minerals Information Team of the USGS.

Date of Government Version: 04/14/2011
Date Data Arrived at EDR: 06/08/2011
Date Made Active in Reports: 09/13/2011
Number of Days to Update: 97

Source: USGS
Telephone: 703-648-7709
Last EDR Contact: 08/31/2018
Next Scheduled EDR Contact: 12/10/2018
Data Release Frequency: Varies

ABANDONED MINES: Abandoned Mines

An inventory of land and water impacted by past mining (primarily coal mining) is maintained by OSMRE to provide information needed to implement the Surface Mining Control and Reclamation Act of 1977 (SMCRA). The inventory contains information on the location, type, and extent of AML impacts, as well as, information on the cost associated with the reclamation of those problems. The inventory is based upon field surveys by State, Tribal, and OSMRE program officials. It is dynamic to the extent that it is modified as new problems are identified and existing problems are reclaimed.

Date of Government Version: 09/10/2018
Date Data Arrived at EDR: 09/11/2018
Date Made Active in Reports: 09/14/2018
Number of Days to Update: 3

Source: Department of Interior
Telephone: 202-208-2609
Last EDR Contact: 09/10/2018
Next Scheduled EDR Contact: 12/24/2018
Data Release Frequency: Quarterly

FINDS: Facility Index System/Facility Registry System

Facility Index System. FINDS contains both facility information and 'pointers' to other sources that contain more detail. EDR includes the following FINDS databases in this report: PCS (Permit Compliance System), AIRS (Aerometric Information Retrieval System), DOCKET (Enforcement Docket used to manage and track information on civil judicial enforcement cases for all environmental statutes), FURS (Federal Underground Injection Control), C-DOCKET (Criminal Docket System used to track criminal enforcement actions for all environmental statutes), FFIS (Federal Facilities Information System), STATE (State Environmental Laws and Statutes), and PADS (PCB Activity Data System).

Date of Government Version: 08/07/2018
Date Data Arrived at EDR: 09/05/2018
Date Made Active in Reports: 10/05/2018
Number of Days to Update: 30

Source: EPA
Telephone: (206) 553-1200
Last EDR Contact: 09/18/2018
Next Scheduled EDR Contact: 12/17/2018
Data Release Frequency: Quarterly

UXO: Unexploded Ordnance Sites

A listing of unexploded ordnance site locations

Date of Government Version: 09/30/2017
Date Data Arrived at EDR: 06/19/2018
Date Made Active in Reports: 09/14/2018
Number of Days to Update: 87

Source: Department of Defense
Telephone: 703-704-1564
Last EDR Contact: 10/15/2018
Next Scheduled EDR Contact: 01/28/2019
Data Release Frequency: Varies

DOCKET HWC: Hazardous Waste Compliance Docket Listing

A complete list of the Federal Agency Hazardous Waste Compliance Docket Facilities.

Date of Government Version: 05/31/2018
Date Data Arrived at EDR: 07/26/2018
Date Made Active in Reports: 10/05/2018
Number of Days to Update: 71

Source: Environmental Protection Agency
Telephone: 202-564-0527
Last EDR Contact: 08/31/2018
Next Scheduled EDR Contact: 12/10/2018
Data Release Frequency: Varies

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

ECHO: Enforcement & Compliance History Information

ECHO provides integrated compliance and enforcement information for about 800,000 regulated facilities nationwide.

Date of Government Version: 09/02/2018
Date Data Arrived at EDR: 09/05/2018
Date Made Active in Reports: 09/14/2018
Number of Days to Update: 9

Source: Environmental Protection Agency
Telephone: 202-564-2280
Last EDR Contact: 09/05/2018
Next Scheduled EDR Contact: 12/17/2018
Data Release Frequency: Quarterly

FUELS PROGRAM: EPA Fuels Program Registered Listing

This listing includes facilities that are registered under the Part 80 (Code of Federal Regulations) EPA Fuels Programs. All companies now are required to submit new and updated registrations.

Date of Government Version: 08/22/2018
Date Data Arrived at EDR: 08/22/2018
Date Made Active in Reports: 10/05/2018
Number of Days to Update: 44

Source: EPA
Telephone: 800-385-6164
Last EDR Contact: 08/22/2018
Next Scheduled EDR Contact: 12/03/2018
Data Release Frequency: Quarterly

AIRS: Oregon Title V Facility Listing

A listing of Title V facility source and emissions information.

Date of Government Version: 07/03/2018
Date Data Arrived at EDR: 07/10/2018
Date Made Active in Reports: 08/17/2018
Number of Days to Update: 38

Source: Department of Environmental Quality
Telephone: 503-229-6459
Last EDR Contact: 10/01/2018
Next Scheduled EDR Contact: 04/17/2047
Data Release Frequency: Annually

COAL ASH: Coal Ash Disposal Sites Listing

A listing of coal ash disposal sites.

Date of Government Version: 12/31/2017
Date Data Arrived at EDR: 03/16/2018
Date Made Active in Reports: 05/15/2018
Number of Days to Update: 60

Source: Department of Environmental Quality
Telephone: 541-298-7255
Last EDR Contact: 08/30/2018
Next Scheduled EDR Contact: 12/17/2018
Data Release Frequency: Varies

DRYCLEANERS: Drycleaning Facilities

A listing of registered drycleaning facilities in Oregon.

Date of Government Version: 07/27/2018
Date Data Arrived at EDR: 07/31/2018
Date Made Active in Reports: 08/15/2018
Number of Days to Update: 15

Source: Department of Environmental Quality
Telephone: 503-229-6783
Last EDR Contact: 07/25/2018
Next Scheduled EDR Contact: 11/12/2018
Data Release Frequency: Annually

ENF: Enforcement Action Listing

Enforcement actions

Date of Government Version: 09/18/2018
Date Data Arrived at EDR: 09/19/2018
Date Made Active in Reports: 10/23/2018
Number of Days to Update: 34

Source: Department of Environmental Quality
Telephone: 503-229-5696
Last EDR Contact: 09/19/2018
Next Scheduled EDR Contact: 12/31/2018
Data Release Frequency: Quarterly

Financial Assurance 1: Financial Assurance Information Listing

Financial assurance information for hazardous waste facilities.

Date of Government Version: 05/21/2018
Date Data Arrived at EDR: 06/21/2018
Date Made Active in Reports: 07/23/2018
Number of Days to Update: 32

Source: Department of Environmental Quality
Telephone: 541-633-2011
Last EDR Contact: 08/30/2018
Next Scheduled EDR Contact: 12/17/2018
Data Release Frequency: Semi-Annually

Financial Assurance 2: Financial Assurance Information Listing

Financial assurance information for solid waste facilities. Financial assurance is intended to ensure that resources are available to pay for the cost of closure, post-closure care, and corrective measures if the owner or operator of a regulated facility is unable or unwilling to pay.

Date of Government Version: 08/20/2018
Date Data Arrived at EDR: 08/21/2018
Date Made Active in Reports: 09/24/2018
Number of Days to Update: 34

Source: Department of Environmental Quality
Telephone: 503-229-5521
Last EDR Contact: 08/20/2018
Next Scheduled EDR Contact: 12/03/2018
Data Release Frequency: Semi-Annually

HSIS: Hazardous Substance Information Survey

Companies in Oregon submitting the Hazardous Substance Information Survey and either reporting or not reporting hazardous substances.

Date of Government Version: 05/03/2018
Date Data Arrived at EDR: 05/03/2018
Date Made Active in Reports: 06/07/2018
Number of Days to Update: 35

Source: State Fire Marshal’s Office
Telephone: 503-373-1540
Last EDR Contact: 08/01/2018
Next Scheduled EDR Contact: 11/12/2018
Data Release Frequency: Semi-Annually

OR MANIFEST: Manifest Information

Hazardous waste manifest information.

Date of Government Version: 12/31/2017
Date Data Arrived at EDR: 08/06/2018
Date Made Active in Reports: 08/15/2018
Number of Days to Update: 9

Source: Department of Environmental Quality
Telephone: N/A
Last EDR Contact: 08/01/2018
Next Scheduled EDR Contact: 11/19/2018
Data Release Frequency: Annually

NPDES: Wastewater Permits Database

A listing of permitted wastewater facilities.

Date of Government Version: 09/20/2018
Date Data Arrived at EDR: 09/20/2018
Date Made Active in Reports: 10/22/2018
Number of Days to Update: 32

Source: Department of Environmental Quality
Telephone: 503-229-5657
Last EDR Contact: 08/01/2018
Next Scheduled EDR Contact: 11/19/2018
Data Release Frequency: Varies

UIC: Underground Injection Control Program Database

DEQ’s Underground Injection Control Program is authorized by the Environmental Protection Agency (EPA) to regulate all underground injection in Oregon to protect groundwater resources.

Date of Government Version: 09/25/2018
Date Data Arrived at EDR: 09/27/2018
Date Made Active in Reports: 10/23/2018
Number of Days to Update: 26

Source: Department of Environmental Quality
Telephone: 503-229-5945
Last EDR Contact: 09/25/2018
Next Scheduled EDR Contact: 01/07/2019
Data Release Frequency: Quarterly

EDR HIGH RISK HISTORICAL RECORDS

EDR Exclusive Records

EDR MGP: EDR Proprietary Manufactured Gas Plants

The EDR Proprietary Manufactured Gas Plant Database includes records of coal gas plants (manufactured gas plants) compiled by EDR’s researchers. Manufactured gas sites were used in the United States from the 1800’s to 1950’s to produce a gas that could be distributed and used as fuel. These plants used whale oil, rosin, coal, or a mixture of coal, oil, and water that also produced a significant amount of waste. Many of the byproducts of the gas production, such as coal tar (oily waste containing volatile and non-volatile chemicals), sludges, oils and other compounds are potentially hazardous to human health and the environment. The byproduct from this process was frequently disposed of directly at the plant site and can remain or spread slowly, serving as a continuous source of soil and groundwater contamination.

Date of Government Version: N/A
Date Data Arrived at EDR: N/A
Date Made Active in Reports: N/A
Number of Days to Update: N/A

Source: EDR, Inc.
Telephone: N/A
Last EDR Contact: N/A
Next Scheduled EDR Contact: N/A
Data Release Frequency: No Update Planned

EDR Hist Auto: EDR Exclusive Historical Auto Stations

EDR has searched selected national collections of business directories and has collected listings of potential gas station/filling station/service station sites that were available to EDR researchers. EDR's review was limited to those categories of sources that might, in EDR's opinion, include gas station/filling station/service station establishments. The categories reviewed included, but were not limited to gas, gas station, gasoline station, filling station, auto, automobile repair, auto service station, service station, etc. This database falls within a category of information EDR classifies as "High Risk Historical Records", or HRHR. EDR's HRHR effort presents unique and sometimes proprietary data about past sites and operations that typically create environmental concerns, but may not show up in current government records searches.

Date of Government Version: N/A
Date Data Arrived at EDR: N/A
Date Made Active in Reports: N/A
Number of Days to Update: N/A

Source: EDR, Inc.
Telephone: N/A
Last EDR Contact: N/A
Next Scheduled EDR Contact: N/A
Data Release Frequency: Varies

EDR Hist Cleaner: EDR Exclusive Historical Cleaners

EDR has searched selected national collections of business directories and has collected listings of potential dry cleaner sites that were available to EDR researchers. EDR's review was limited to those categories of sources that might, in EDR's opinion, include dry cleaning establishments. The categories reviewed included, but were not limited to dry cleaners, cleaners, laundry, laundromat, cleaning/laundry, wash & dry etc. This database falls within a category of information EDR classifies as "High Risk Historical Records", or HRHR. EDR's HRHR effort presents unique and sometimes proprietary data about past sites and operations that typically create environmental concerns, but may not show up in current government records searches.

Date of Government Version: N/A
Date Data Arrived at EDR: N/A
Date Made Active in Reports: N/A
Number of Days to Update: N/A

Source: EDR, Inc.
Telephone: N/A
Last EDR Contact: N/A
Next Scheduled EDR Contact: N/A
Data Release Frequency: Varies

EDR RECOVERED GOVERNMENT ARCHIVES

Exclusive Recovered Govt. Archives

RGA HWS: Recovered Government Archive State Hazardous Waste Facilities List

The EDR Recovered Government Archive State Hazardous Waste database provides a list of SHWS incidents derived from historical databases and includes many records that no longer appear in current government lists. Compiled from Records formerly available from the Department of Environmental Quality in Oregon.

Date of Government Version: N/A
Date Data Arrived at EDR: 07/01/2013
Date Made Active in Reports: 01/03/2014
Number of Days to Update: 186

Source: Department of Environmental Quality
Telephone: N/A
Last EDR Contact: 06/01/2012
Next Scheduled EDR Contact: N/A
Data Release Frequency: Varies

RGA LF: Recovered Government Archive Solid Waste Facilities List

The EDR Recovered Government Archive Landfill database provides a list of landfills derived from historical databases and includes many records that no longer appear in current government lists. Compiled from Records formerly available from the Department of Environmental Quality in Oregon.

Date of Government Version: N/A
Date Data Arrived at EDR: 07/01/2013
Date Made Active in Reports: 01/13/2014
Number of Days to Update: 196

Source: Department of Environmental Quality
Telephone: N/A
Last EDR Contact: 06/01/2012
Next Scheduled EDR Contact: N/A
Data Release Frequency: Varies

RGA LUST: Recovered Government Archive Leaking Underground Storage Tank

The EDR Recovered Government Archive Leaking Underground Storage Tank database provides a list of LUST incidents derived from historical databases and includes many records that no longer appear in current government lists. Compiled from Records formerly available from the Department of Environmental Quality in Oregon.

Date of Government Version: N/A	Source: Department of Environmental Quality
Date Data Arrived at EDR: 07/01/2013	Telephone: N/A
Date Made Active in Reports: 12/27/2013	Last EDR Contact: 06/01/2012
Number of Days to Update: 179	Next Scheduled EDR Contact: N/A
	Data Release Frequency: Varies

OTHER DATABASE(S)

Depending on the geographic area covered by this report, the data provided in these specialty databases may or may not be complete. For example, the existence of wetlands information data in a specific report does not mean that all wetlands in the area covered by the report are included. Moreover, the absence of any reported wetlands information does not necessarily mean that wetlands do not exist in the area covered by the report.

NY MANIFEST: Facility and Manifest Data

Manifest is a document that lists and tracks hazardous waste from the generator through transporters to a TSD facility.

Date of Government Version: 07/01/2018	Source: Department of Environmental Conservation
Date Data Arrived at EDR: 08/01/2018	Telephone: 518-402-8651
Date Made Active in Reports: 08/31/2018	Last EDR Contact: 08/01/2018
Number of Days to Update: 30	Next Scheduled EDR Contact: 11/12/2018
	Data Release Frequency: Quarterly

WI MANIFEST: Manifest Information

Hazardous waste manifest information.

Date of Government Version: 12/31/2017	Source: Department of Natural Resources
Date Data Arrived at EDR: 06/15/2018	Telephone: N/A
Date Made Active in Reports: 07/09/2018	Last EDR Contact: 09/06/2018
Number of Days to Update: 24	Next Scheduled EDR Contact: 12/24/2018
	Data Release Frequency: Annually

Oil/Gas Pipelines

Source: PennWell Corporation

Petroleum Bundle (Crude Oil, Refined Products, Petrochemicals, Gas Liquids (LPG/NGL), and Specialty Gases (Miscellaneous)) N = Natural Gas Bundle (Natural Gas, Gas Liquids (LPG/NGL), and Specialty Gases (Miscellaneous)). This map includes information copyrighted by PennWell Corporation. This information is provided on a best effort basis and PennWell Corporation does not guarantee its accuracy nor warrant its fitness for any particular purpose. Such information has been reprinted with the permission of PennWell.

Electric Power Transmission Line Data

Source: PennWell Corporation

This map includes information copyrighted by PennWell Corporation. This information is provided on a best effort basis and PennWell Corporation does not guarantee its accuracy nor warrant its fitness for any particular purpose. Such information has been reprinted with the permission of PennWell.

Sensitive Receptors: There are individuals deemed sensitive receptors due to their fragile immune systems and special sensitivity to environmental discharges. These sensitive receptors typically include the elderly, the sick, and children. While the location of all sensitive receptors cannot be determined, EDR indicates those buildings and facilities - schools, daycares, hospitals, medical centers, and nursing homes - where individuals who are sensitive receptors are likely to be located.

AHA Hospitals:

Source: American Hospital Association, Inc.
Telephone: 312-280-5991
The database includes a listing of hospitals based on the American Hospital Association’s annual survey of hospitals.

Medical Centers: Provider of Services Listing
Source: Centers for Medicare & Medicaid Services
Telephone: 410-786-3000
A listing of hospitals with Medicare provider number, produced by Centers of Medicare & Medicaid Services, a federal agency within the U.S. Department of Health and Human Services.

Nursing Homes
Source: National Institutes of Health
Telephone: 301-594-6248
Information on Medicare and Medicaid certified nursing homes in the United States.

Public Schools
Source: National Center for Education Statistics
Telephone: 202-502-7300
The National Center for Education Statistics' primary database on elementary and secondary public education in the United States. It is a comprehensive, annual, national statistical database of all public elementary and secondary schools and school districts, which contains data that are comparable across all states.

Private Schools
Source: National Center for Education Statistics
Telephone: 202-502-7300
The National Center for Education Statistics' primary database on private school locations in the United States.

Daycare Centers: Child Care Listings
Source: Employment Department
Telephone: 503-947-1420

Flood Zone Data: This data was obtained from the Federal Emergency Management Agency (FEMA). It depicts 100-year and 500-year flood zones as defined by FEMA. It includes the National Flood Hazard Layer (NFHL) which incorporates Flood Insurance Rate Map (FIRM) data and Q3 data from FEMA in areas not covered by NFHL.
Source: FEMA
Telephone: 877-336-2627
Date of Government Version: 2003, 2015

NWI: National Wetlands Inventory. This data, available in select counties across the country, was obtained by EDR in 2002, 2005 and 2010 from the U.S. Fish and Wildlife Service.

State Wetlands Data: Wetlands Inventory Data
Source: Oregon Geospatial Enterprise Office
Telephone: 503-378-2166

Current USGS 7.5 Minute Topographic Map
Source: U.S. Geological Survey

STREET AND ADDRESS INFORMATION

GEOCHECK ®- PHYSICAL SETTING SOURCE ADDENDUM

TARGET PROPERTY ADDRESS

REDMOND BIAK COUTES
2522 SE JESSE BUTLER CIR
REDMOND, OR 97756

TARGET PROPERTY COORDINATES

Latitude (North):	44.255065 - 44˚ 15’ 18.23’’
Longitude (West):	121.131854 - 121˚ 7’ 54.67’’
Universal Tranverse Mercator:	Zone 10
UTM X (Meters):	649138.9
UTM Y (Meters):	4901683.5
Elevation:	3069 ft. above sea level

USGS TOPOGRAPHIC MAP

Target Property Map:	6067500 REDMOND, OR
Version Date:	2014
Northeast Map:	6067530 O’NEIL, OR
Version Date:	2014
Southeast Map:	6067496 POWELL BUTTE, OR
Version Date:	2014
Southwest Map:	6067448 FORKED HORN BUTTE, OR
Version Date:	2014

EDR’s GeoCheck Physical Setting Source Addendum is provided to assist the environmental professional in forming an opinion about the impact of potential contaminant migration.

Assessment of the impact of contaminant migration generally has two principle investigative components:

1. Groundwater flow direction, and
2. Groundwater flow velocity.

Groundwater flow direction may be impacted by surface topography, hydrology, hydrogeology, characteristics of the soil, and nearby wells. Groundwater flow velocity is generally impacted by the nature of the geologic strata.

GEOCHECK® - PHYSICAL SETTING SOURCE SUMMARY

GROUNDWATER FLOW DIRECTION INFORMATION

Groundwater flow direction for a particular site is best determined by a qualified environmental professional using site-specific well data. If such data is not reasonably ascertainable, it may be necessary to rely on other sources of information, such as surface topographic information, hydrologic information, hydrogeologic data collected on nearby properties, and regional groundwater flow information (from deep aquifers).

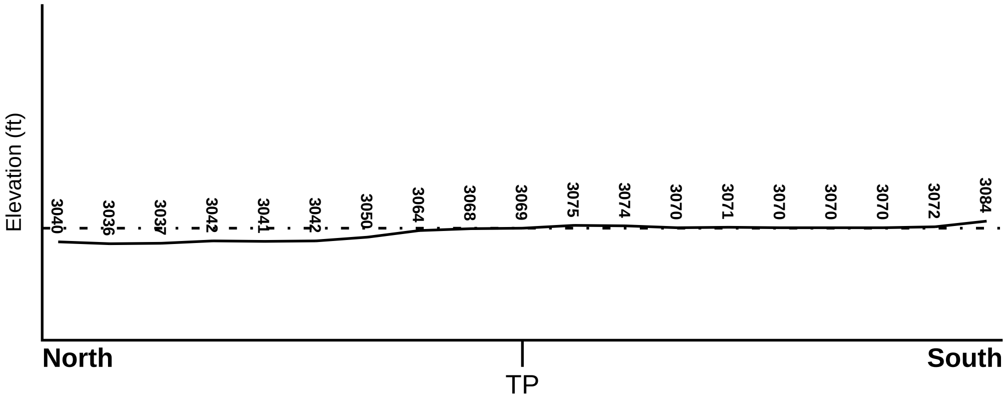
TOPOGRAPHIC INFORMATION

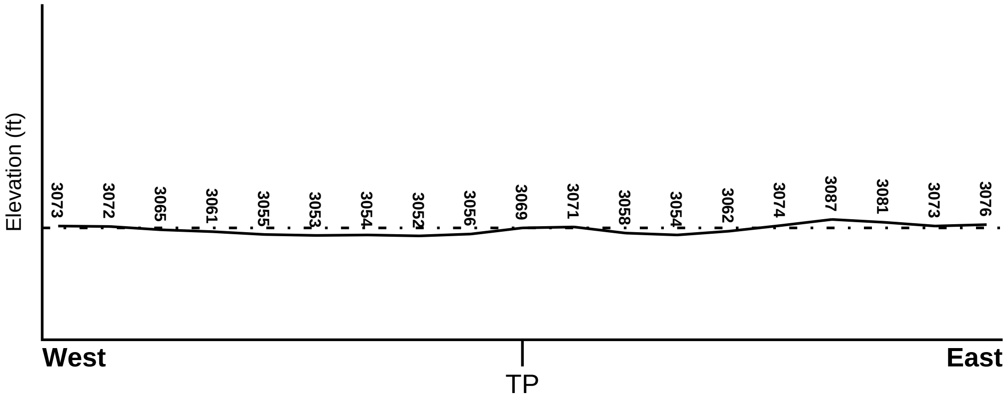
Surface topography may be indicative of the direction of surficial groundwater flow. This information can be used to assist the environmental professional in forming an opinion about the impact of nearby contaminated properties or, should contamination exist on the target property, what downgradient sites might be impacted.

TARGET PROPERTY TOPOGRAPHY

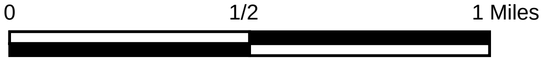
General Topographic Gradient: General North

SURROUNDING TOPOGRAPHY: ELEVATION PROFILES





Target Property Elevation: 3069 ft.



Source: Topography has been determined from the USGS 7.5' Digital Elevation Model and should be evaluated on a relative (not an absolute) basis. Relative elevation information between sites of close proximity should be field verified.

GEOCHECK® - PHYSICAL SETTING SOURCE SUMMARY

HYDROLOGIC INFORMATION

Surface water can act as a hydrologic barrier to groundwater flow. Such hydrologic information can be used to assist the environmental professional in forming an opinion about the impact of nearby contaminated properties or, should contamination exist on the target property, what downgradient sites might be impacted.

Refer to the Physical Setting Source Map following this summary for hydrologic information (major waterways and bodies of water).

FEMA FLOOD ZONE

Flood Plain Panel at Target Property	FEMA Source Type
41017C0325E	FEMA FIRM Flood data

Additional Panels in search area:	FEMA Source Type
41017C0350E	FEMA FIRM Flood data
41017C0150C	FEMA Q3 Flood data
41017C0525E	FEMA FIRM Flood data

NATIONAL WETLAND INVENTORY

NWI Quad at Target Property	NWI Electronic Data Coverage
REDMOND	YES - refer to the Overview Map and Detail Map

HYDROGEOLOGIC INFORMATION

Hydrogeologic information obtained by installation of wells on a specific site can often be an indicator of groundwater flow direction in the immediate area. Such hydrogeologic information can be used to assist the environmental professional in forming an opinion about the impact of nearby contaminated properties or, should contamination exist on the target property, what downgradient sites might be impacted.

AQUIFLOW®

Search Radius: 1.000 Mile.

EDR has developed the AQUIFLOW Information System to provide data on the general direction of groundwater flow at specific points. EDR has reviewed reports submitted by environmental professionals to regulatory authorities at select sites and has extracted the date of the report, groundwater flow direction as determined hydrogeologically, and the depth to water table.

MAP ID	LOCATION FROM TP	GENERAL DIRECTION GROUNDWATER FLOW
Not Reported		

GEOCHECK® - PHYSICAL SETTING SOURCE SUMMARY

GROUNDWATER FLOW VELOCITY INFORMATION

Groundwater flow velocity information for a particular site is best determined by a qualified environmental professional using site specific geologic and soil strata data. If such data are not reasonably ascertainable, it may be necessary to rely on other sources of information, including geologic age identification, rock stratigraphic unit and soil characteristics data collected on nearby properties and regional soil information. In general, contaminant plumes move more quickly through sandy-gravelly types of soils than silty-clayey types of soils.

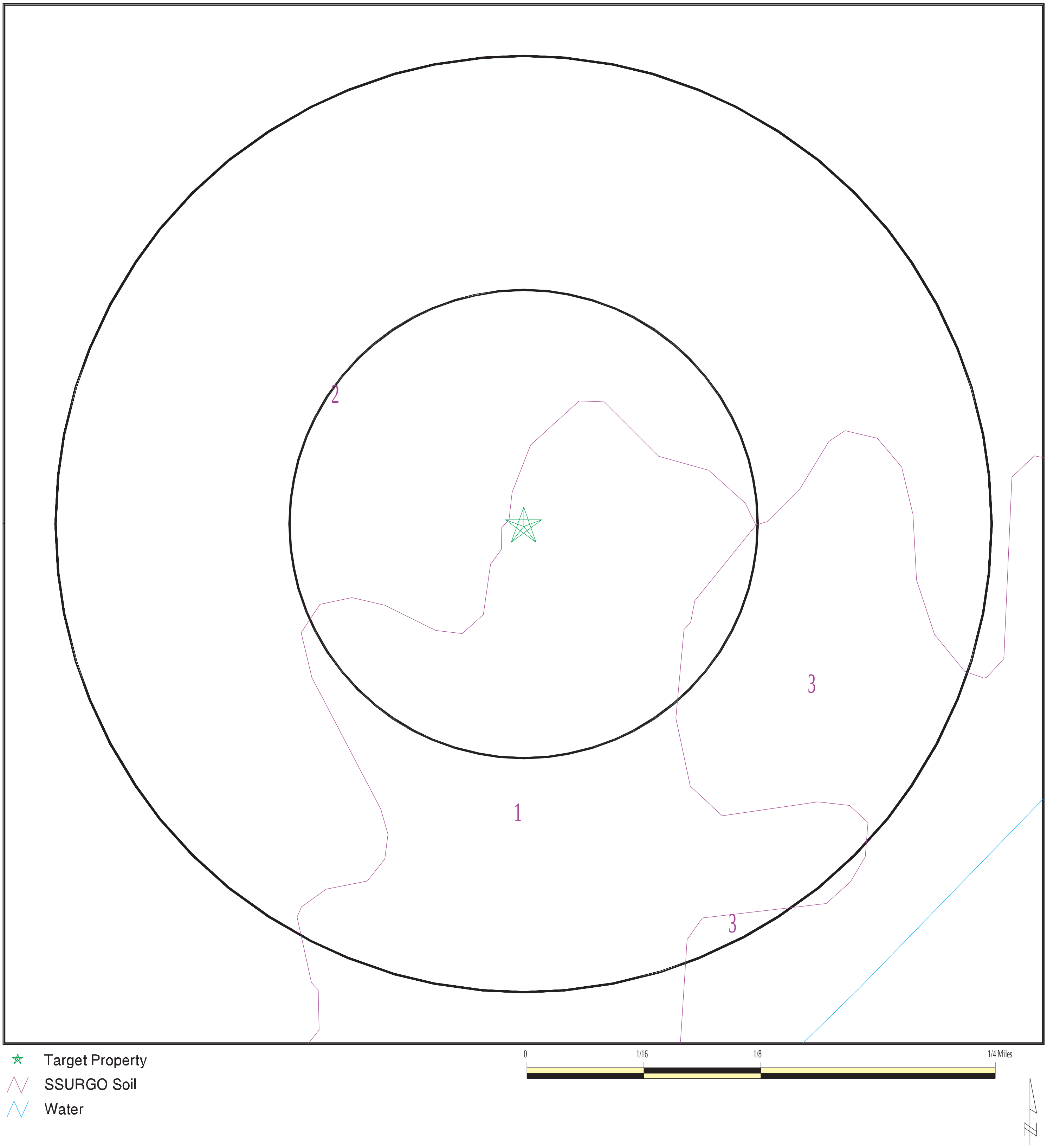
GEOLOGIC INFORMATION IN GENERAL AREA OF TARGET PROPERTY

Geologic information can be used by the environmental professional in forming an opinion about the relative speed at which contaminant migration may be occurring.

ROCK STRATIGRAPHIC UNIT		**GEOLOGIC AGE IDENTIFICATION**	
Era:	Cenozoic	Category:	Volcanic Rocks
System:	Quaternary		
Series:	Quaternary volcanic rocks		
Code:	Qv *(decoded above as Era, System & Series)*		

Geologic Age and Rock Stratigraphic Unit Source: P.G. Schruben, R.E. Arndt and W.J. Bawiec, Geology of the Conterminous U.S. at 1:2,500,000 Scale - a digital representation of the 1974 P.B. King and H.M. Beikman Map, USGS Digital Data Series DDS - 11 (1994).

SSURGO SOIL MAP - 5464928.2s



SITE NAME: Redmond BIAK COUTES
ADDRESS: 2522 SE Jesse Butler Cir
Redmond OR 97756
LAT/LONG: 44.255065 / 121.131854

CLIENT: AECOM
CONTACT: Brittany Kirchmann
INQUIRY #: 5464928.2s
DATE: October 25, 2018 11:42 am

DOMINANT SOIL COMPOSITION IN GENERAL AREA OF TARGET PROPERTY

The U.S. Department of Agriculture’s (USDA) Soil Conservation Service (SCS) leads the National Cooperative Soil Survey (NCSS) and is responsible for collecting, storing, maintaining and distributing soil survey information for privately owned lands in the United States. A soil map in a soil survey is a representation of soil patterns in a landscape. The following information is based on Soil Conservation Service SSURGO data.

Soil Map ID: 1

Soil Component Name:	Stukel
Soil Surface Texture:	sandy loam
Hydrologic Group:	Class C - Slow infiltration rates. Soils with layers impeding downward movement of water, or soils with moderately fine or fine textures.
Soil Drainage Class:	Well drained
Hydric Status: Not hydric	
Corrosion Potential - Uncoated Steel:	Moderate
Depth to Bedrock Min:	> 0 inches
Depth to Watertable Min:	> 0 inches

Soil Layer Information

	Boundary			Classification			
Layer	Upper	Lower	Soil Texture Class	AASHTO Group	Unified Soil	Saturated hydraulic conductivity micro m/sec	Soil Reaction (pH)
1	0 inches	3 inches	sandy loam	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:
2	3 inches	11 inches	cobbly sandy loam	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:
3	11 inches	18 inches	gravelly sandy loam	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:

Soil Layer Information							
	Boundary			Classification		Saturated hydraulic conductivity micro m/sec	Soil Reaction (pH)
Layer	Upper	Lower	Soil Texture Class	AASHTO Group	Unified Soil		
4	18 inches	27 inches	unweathered bedrock	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:

Soil Map ID: 2

Soil Component Name: Deschutes

Soil Surface Texture: sandy loam

Hydrologic Group: Class B - Moderate infiltration rates. Deep and moderately deep, moderately well and well drained soils with moderately coarse textures.

Soil Drainage Class: Well drained

Hydric Status: Not hydric

Corrosion Potential - Uncoated Steel: Moderate

Depth to Bedrock Min: > 46 inches

Depth to Watertable Min: > 0 inches

Soil Layer Information							
	Boundary			Classification		Saturated hydraulic conductivity micro m/sec	Soil Reaction (pH)
Layer	Upper	Lower	Soil Texture Class	AASHTO Group	Unified Soil		
1	0 inches	7 inches	sandy loam	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:
2	7 inches	16 inches	sandy loam	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:

Soil Layer Information							
	Boundary			Classification		Saturated hydraulic conductivity micro m/sec	Soil Reaction (pH)
Layer	Upper	Lower	Soil Texture Class	AASHTO Group	Unified Soil		
3	16 inches	31 inches	sandy loam	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:
4	31 inches	40 inches	unweathered bedrock	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:

Soil Map ID: 3

Soil Component Name:	Redmond
Soil Surface Texture:	sandy loam
Hydrologic Group:	Class C - Slow infiltration rates. Soils with layers impeding downward movement of water, or soils with moderately fine or fine textures.
Soil Drainage Class:	Well drained

Hydric Status: Not hydric

Corrosion Potential - Uncoated Steel:	High
Depth to Bedrock Min:	> 53 inches
Depth to Watertable Min:	> 0 inches

Soil Layer Information							
	Boundary			Classification		Saturated hydraulic conductivity micro m/sec	Soil Reaction (pH)
Layer	Upper	Lower	Soil Texture Class	AASHTO Group	Unified Soil		
1	0 inches	11 inches	sandy loam	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:

Soil Layer Information							
	Boundary			Classification			
Layer	Upper	Lower	Soil Texture Class	AASHTO Group	Unified Soil	Saturated hydraulic conductivity micro m/sec	Soil Reaction (pH)
2	11 inches	20 inches	loam	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:
3	20 inches	31 inches	unweathered bedrock	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:

LOCAL / REGIONAL WATER AGENCY RECORDS

EDR Local/Regional Water Agency records provide water well information to assist the environmental professional in assessing sources that may impact ground water flow direction, and in forming an opinion about the impact of contaminant migration on nearby drinking water wells.

WELL SEARCH DISTANCE INFORMATION

DATABASE	SEARCH DISTANCE (miles)
Federal USGS	1.000
Federal FRDS PWS	Nearest PWS within 1 mile
State Database	1.000

FEDERAL USGS WELL INFORMATION

MAP ID	WELL ID	LOCATION FROM TP
A1	USGS40000989545	0 - 1/8 Mile WSW
B4	USGS40000989581	1/2 - 1 Mile NNW

FEDERAL FRDS PUBLIC WATER SUPPLY SYSTEM INFORMATION

MAP ID	WELL ID	LOCATION FROM TP

No PWS System Found

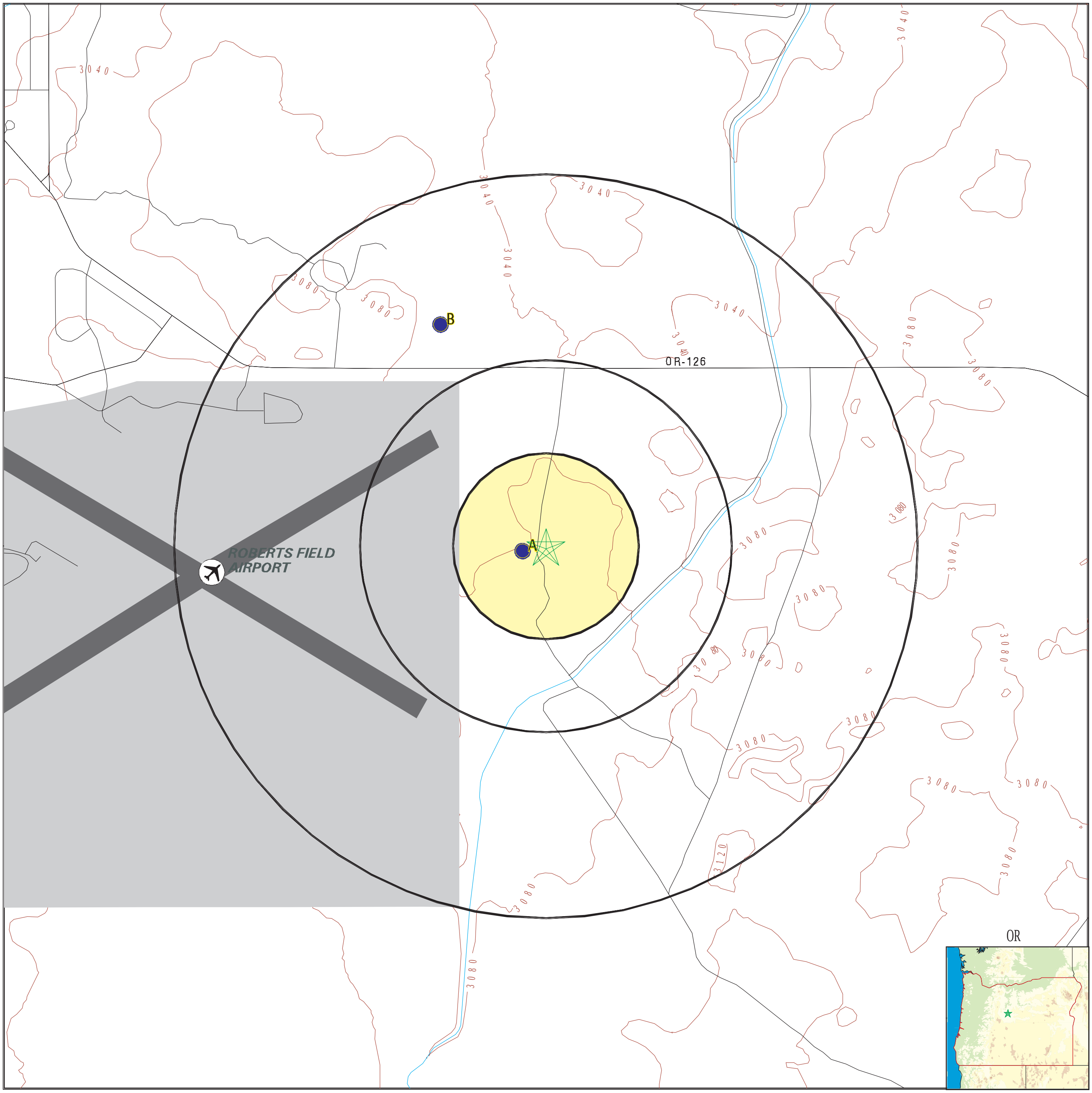
Note: PWS System location is not always the same as well location.

GEOCHECK® - PHYSICAL SETTING SOURCE SUMMARY

STATE DATABASE WELL INFORMATION

MAP ID	WELL ID	LOCATION FROM TP
A2	ORW600000010032	0 - 1/8 Mile West
B3	ORW600000009131	1/2 - 1 Mile NNW

PHYSICAL SETTING SOURCE MAP - 5464928.2s



0 1/4 1/2 1 Miles

- County Boundary
- Major Roads
- Contour Lines
- Airports
- Earthquake epicenter, Richter 5 or greater
- Ⓦ Water Wells
- Ⓟ Public Water Supply Wells
- ● Cluster of Multiple Icons

- Groundwater Flow Direction
- GI Indeterminate Groundwater Flow at Location
- GV Groundwater Flow Varies at Location
- ● Oil, gas or related wells

SITE NAME: Redmond BIAK COUTES
ADDRESS: 2522 SE Jesse Butler Cir
Redmond OR 97756
LAT/LONG: 44.255065 / 121.131854

CLIENT: AECOM
CONTACT: Brittany Kirchmann
INQUIRY #: 5464928.2s
DATE: October 25, 2018 11:42 am

Map ID Direction Distance Elevation	Database	EDR ID Number
A1 **WSW** **0 - 1/8 Mile** **Lower**	**FED USGS**	**USGS40000989545**

Organization ID:	USGS-OR	Organization Name:	USGS Oregon Water Science Center
Monitor Location:	15S/13E-23ADC	Type:	Well
Description:	Not Reported	HUC:	17070301
Drainage Area:	Not Reported	Drainage Area Units:	Not Reported
Contrib Drainage Area:	Not Reported	Contrib Drainage Area Unts:	Not Reported
Aquifer:	Not Reported	Formation Type:	Not Reported
Aquifer Type:	Not Reported	Construction Date:	19790216
Well Depth:	420	Well Depth Units:	ft
Well Hole Depth:	425	Well Hole Depth Units:	ft

Ground water levels,Number of Measurements:	1	Level reading date:	1979-07-13
Feet below surface:	310.16	Feet to sea level:	Not Reported
Note:	Not Reported		

A2 **West** **0 - 1/8 Mile** **Lower**	**OR WELLS**	**ORW600000010032**

Well Log ID:	DESC 3954	Last Update:	01/06/2008
Well Tag:	0	State Obs Well #:	0
Observation Well:	Not Reported	Recorder Well:	Not Reported
Obs Well Flag:	Not Reported	Surface Elevation:	3058

B3 **NNW** **1/2 - 1 Mile** **Lower**	**OR WELLS**	**ORW600000009131**

Well Log ID:	DESC 3878	Last Update:	01/06/2008
Well Tag:	0	State Obs Well #:	0
Observation Well:	Not Reported	Recorder Well:	Not Reported
Obs Well Flag:	Not Reported	Surface Elevation:	3075

B4 **NNW** **1/2 - 1 Mile** **Lower**	**FED USGS**	**USGS40000989581**

Organization ID:	USGS-OR	Organization Name:	USGS Oregon Water Science Center
Monitor Location:	15S/13E-14DCC	Type:	Well
Description:	Not Reported	HUC:	17070301
Drainage Area:	Not Reported	Drainage Area Units:	Not Reported
Contrib Drainage Area:	Not Reported	Contrib Drainage Area Unts:	Not Reported
Aquifer:	Not Reported	Formation Type:	Not Reported
Aquifer Type:	Not Reported	Construction Date:	19790306
Well Depth:	370	Well Depth Units:	ft
Well Hole Depth:	370	Well Hole Depth Units:	ft

Ground water levels,Number of Measurements:	1	Level reading date:	1979-03-06
Feet below surface:	330.00	Feet to sea level:	Not Reported
Note:	Not Reported		

GEOCHECK® - PHYSICAL SETTING SOURCE MAP FINDINGS
RADON

AREA RADON INFORMATION

State Database: OR Radon

Radon Test Results

Zipcode	Num Tests	Maximum	Minimum	Average	# > 4 pCi/L
97756	10	1.3	0.2	0.4	0

Federal EPA Radon Zone for DESCHUTES County: 3

Note: Zone 1 indoor average level > 4 pCi/L.
: Zone 2 indoor average level >= 2 pCi/L and <= 4 pCi/L.
: Zone 3 indoor average level < 2 pCi/L.

Federal Area Radon Information for DESCHUTES COUNTY, OR

Number of sites tested: 11

Area	Average Activity	% <4 pCi/L	% 4-20 pCi/L	% >20 pCi/L
Living Area	0.820 pCi/L	100%	0%	0%
Basement	Not Reported	Not Reported	Not Reported	Not Reported

PHYSICAL SETTING SOURCE RECORDS SEARCHED

TOPOGRAPHIC INFORMATION

USGS 7.5' Digital Elevation Model (DEM)
Source: United States Geologic Survey
EDR acquired the USGS 7.5' Digital Elevation Model in 2002 and updated it in 2006. The 7.5 minute DEM corresponds to the USGS 1:24,000- and 1:25,000-scale topographic quadrangle maps. The DEM provides elevation data with consistent elevation units and projection.

Current USGS 7.5 Minute Topographic Map
Source: U.S. Geological Survey

HYDROLOGIC INFORMATION

Flood Zone Data: This data was obtained from the Federal Emergency Management Agency (FEMA). It depicts 100-year and 500-year flood zones as defined by FEMA. It includes the National Flood Hazard Layer (NFHL) which incorporates Flood Insurance Rate Map (FIRM) data and Q3 data from FEMA in areas not covered by NFHL.
Source: FEMA
Telephone: 877-336-2627
Date of Government Version: 2003, 2015

NWI: National Wetlands Inventory. This data, available in select counties across the country, was obtained by EDR in 2002, 2005 and 2010 from the U.S. Fish and Wildlife Service.

State Wetlands Data: Wetlands Inventory Data
Source: Oregon Geospatial Enterprise Office
Telephone: 503-378-2166

HYDROGEOLOGIC INFORMATION

AQUIFLOW^{R} Information System
Source: EDR proprietary database of groundwater flow information
EDR has developed the AQUIFLOW Information System (AIS) to provide data on the general direction of groundwater flow at specific points. EDR has reviewed reports submitted to regulatory authorities at select sites and has extracted the date of the report, hydrogeologically determined groundwater flow direction and depth to water table information.

GEOLOGIC INFORMATION

Geologic Age and Rock Stratigraphic Unit
Source: P.G. Schruben, R.E. Arndt and W.J. Bawiec, Geology of the Conterminous U.S. at 1:2,500,000 Scale - A digital representation of the 1974 P.B. King and H.M. Beikman Map, USGS Digital Data Series DDS - 11 (1994).

STATSGO: State Soil Geographic Database
Source: Department of Agriculture, Natural Resources Conservation Service (NRCS)
The U.S. Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS) leads the national Conservation Soil Survey (NCSS) and is responsible for collecting, storing, maintaining and distributing soil survey information for privately owned lands in the United States. A soil map in a soil survey is a representation of soil patterns in a landscape. Soil maps for STATSGO are compiled by generalizing more detailed (SSURGO) soil survey maps.

SSURGO: Soil Survey Geographic Database
Source: Department of Agriculture, Natural Resources Conservation Service (NRCS)
Telephone: 800-672-5559
SSURGO is the most detailed level of mapping done by the Natural Resources Conservation Service, mapping scales generally range from 1:12,000 to 1:63,360. Field mapping methods using national standards are used to construct the soil maps in the Soil Survey Geographic (SSURGO) database. SSURGO digitizing duplicates the original soil survey maps. This level of mapping is designed for use by landowners, townships and county natural resource planning and management.

PHYSICAL SETTING SOURCE RECORDS SEARCHED

LOCAL / REGIONAL WATER AGENCY RECORDS

FEDERAL WATER WELLS

PWS: Public Water Systems
Source: EPA/Office of Drinking Water
Telephone: 202-564-3750
Public Water System data from the Federal Reporting Data System. A PWS is any water system which provides water to at least 25 people for at least 60 days annually. PWSs provide water from wells, rivers and other sources.

PWS ENF: Public Water Systems Violation and Enforcement Data
Source: EPA/Office of Drinking Water
Telephone: 202-564-3750
Violation and Enforcement data for Public Water Systems from the Safe Drinking Water Information System (SDWIS) after August 1995. Prior to August 1995, the data came from the Federal Reporting Data System (FRDS).

USGS Water Wells: USGS National Water Inventory System (NWIS)
This database contains descriptive information on sites where the USGS collects or has collected data on surface water and/or groundwater. The groundwater data includes information on wells, springs, and other sources of groundwater.

STATE RECORDS

Water Well Data
Source: Department of Water Resources
Telephone: 503-986-0843

OTHER STATE DATABASE INFORMATION

Oil and Gas Well Locations
Source: Department of Geology and Mineral Industries
Telephone: 971-673-1540
A listing of oil and gas well locations in the state.

RADON

State Database: OR Radon
Source: Oregon Health Services
Telephone: 503-731-4272
Radon Levels in Orgeon

Area Radon Information
Source: USGS
Telephone: 703-356-4020
The National Radon Database has been developed by the U.S. Environmental Protection Agency (USEPA) and is a compilation of the EPA/State Residential Radon Survey and the National Residential Radon Survey. The study covers the years 1986 - 1992. Where necessary data has been supplemented by information collected at private sources such as universities and research institutions.

EPA Radon Zones
Source: EPA
Telephone: 703-356-4020
Sections 307 & 309 of IRAA directed EPA to list and identify areas of U.S. with the potential for elevated indoor radon levels.

OTHER

Airport Landing Facilities: Private and public use landing facilities
Source: Federal Aviation Administration, 800-457-6656

Epicenters: World earthquake epicenters, Richter 5 or greater
Source: Department of Commerce, National Oceanic and Atmospheric Administration

Earthquake Fault Lines: The fault lines displayed on EDR’s Topographic map are digitized quaternary faultlines, prepared in 1975 by the United State Geological Survey

PHYSICAL SETTING SOURCE RECORDS SEARCHED

STREET AND ADDRESS INFORMATION

Redmond BIAK COUTES
2522 SE Jesse Butler Cir
Redmond, OR 97756

Inquiry Number: 5464928.2s
October 25, 2018

EDR Summary Radius Map Report

6 Armstrong Road, 4th floor
Shelton, CT 06484
Toll Free: 800.352.0050
www.edrnet.com

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SECTION **PAGE**

GEOCHECK ADDENDUM

Thank you for your business.
Please contact EDR at 1-800-352-0050
with any questions or comments.

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EXECUTIVE SUMMARY

A search of available environmental records was conducted by Environmental Data Resources, Inc (EDR). The report was designed to assist parties seeking to meet the search requirements of EPA's Standards and Practices for All Appropriate Inquiries (40 CFR Part 312), the ASTM Standard Practice for Environmental Site Assessments (E 1527-13), the ASTM Standard Practice for Environmental Site Assessments for Forestland or Rural Property (E 2247-16), the ASTM Standard Practice for Limited Environmental Due Diligence: Transaction Screen Process (E 1528-14) or custom requirements developed for the evaluation of environmental risk associated with a parcel of real estate.

TARGET PROPERTY INFORMATION

ADDRESS

2522 SE JESSE BUTLER CIR
REDMOND, OR 97756

COORDINATES

Latitude (North):	44.2550650 - 44˚ 15' 18.23''
Longitude (West):	121.1318540 - 121˚ 7' 54.67''
Universal Tranverse Mercator:	Zone 10
UTM X (Meters):	649138.9
UTM Y (Meters):	4901683.5
Elevation:	3069 ft. above sea level

USGS TOPOGRAPHIC MAP ASSOCIATED WITH TARGET PROPERTY

Target Property:	TP
Source:	U.S. Geological Survey
Target Property:	NE
Source:	U.S. Geological Survey
Target Property:	SE
Source:	U.S. Geological Survey
Target Property:	SW
Source:	U.S. Geological Survey

AERIAL PHOTOGRAPHY IN THIS REPORT

Portions of Photo from:	20140605
Source:	USDA

MAPPED SITES SUMMARY

Target Property Address:
2522 SE JESSE BUTLER CIR
REDMOND, OR 97756

Click on Map ID to see full detail.

MAP ID	SITE NAME	ADDRESS	DATABASE ACRONYMS	RELATIVE ELEVATION	DIST (ft. & mi.) DIRECTION
A1		2522 SE JESSE BUTLER	OR HAZMAT		TP
A2	ROBERTS FIELD TERMIN	2522 SE JESSE BUTLER	RGA HWS		TP
A3	REDMOND MUNICIPAL AI	2522 SE JESSE BUTLER	ECSI, VCP, UIC		TP
A4	REDMOND CITY OF	2522 SE JESSE BUTLER	AST, HSIS		TP
A5		2522 SE JESSE BUTLER	OR HAZMAT		TP
6	DESCHUTES CO. PROPER	2555 E HWY 126	ECSI, BROWNFIELDS	Lower	3786, 0.717, WNW
7	BIAK TRAINING CENTER		ECSI	Higher	4344, 0.823, East
B8	REDMOND MUNICIPAL AI	1020-1050 SE SISTERS	ECSI, VCP	Lower	4824, 0.914, WNW
B9	REDMOND MUNICIPAL AI	1020 SE SISTERS AVE	ECSI	Lower	4824, 0.914, WNW
10	MAX MILLS FORMERLY O	HWY 126 (BTWN 27TH &	ECSI, VCP	Lower	4847, 0.918, WNW
B11	DESCHUTES READY MIX	700 SW SISTERS AVE	ECSI, VCP, UIC	Lower	4973, 0.942, WNW

EXECUTIVE SUMMARY

TARGET PROPERTY SEARCH RESULTS

The target property was identified in the following records. For more information on this property see page 8 of the attached EDR Radius Map report:

Site	Database(s)	EPA ID
2522 SE JESSE BUTLER 2522 SE JESSE BUTLER REDMOND, OR 97756	OR HAZMAT Facility Id: 1440852	N/A
ROBERTS FIELD TERMIN 2522 SE JESSE BUTLER REDMOND, OR	RGA HWS	N/A
REDMOND MUNICIPAL AI 2522 SE JESSE BUTLER REDMOND, OR 97756	ECSI Investigation: No Further Action State ID Number: 5121 VCP ECS Site ID: 5121 UIC Facility Status: Applied for permit UIC Number: 12415	N/A
REDMOND CITY OF 2522 SE JESSE BUTLER REDMOND, OR 97756	AST Facility Id: 033518 HSIS Facility Id: 033518	N/A
2522 SE JESSE BUTLER 2522 SE JESSE BUTLER REDMOND, OR 97756	OR HAZMAT Facility Id: 1443274	N/A

SURROUNDING SITES: SEARCH RESULTS

Surrounding sites were identified in the following databases.

Elevations have been determined from the USGS Digital Elevation Model and should be evaluated on a relative (not an absolute) basis. Relative elevation information between sites of close proximity should be field verified. Sites with an elevation equal to or higher than the target property have been differentiated below from sites with an elevation lower than the target property.
Page numbers and map identification numbers refer to the EDR Radius Map report where detailed data on individual sites can be reviewed.

Sites listed in ***bold italics*** are in multiple databases.

Unmappable (orphan) sites are not considered in the foregoing analysis.

EXECUTIVE SUMMARY

ECSI: A review of the ECSI list, as provided by EDR, and dated 10/01/2018 has revealed that there are 6 ECSI sites within approximately 1 mile of the target property.

Equal/Higher Elevation	Address	Direction / Distance	Map ID	Page
BIAK TRAINING CENTER Investigation: No Further Action State ID Number: 5050 State ID Number: 5051		E 1/2 - 1 (0.823 mi.)	7	9

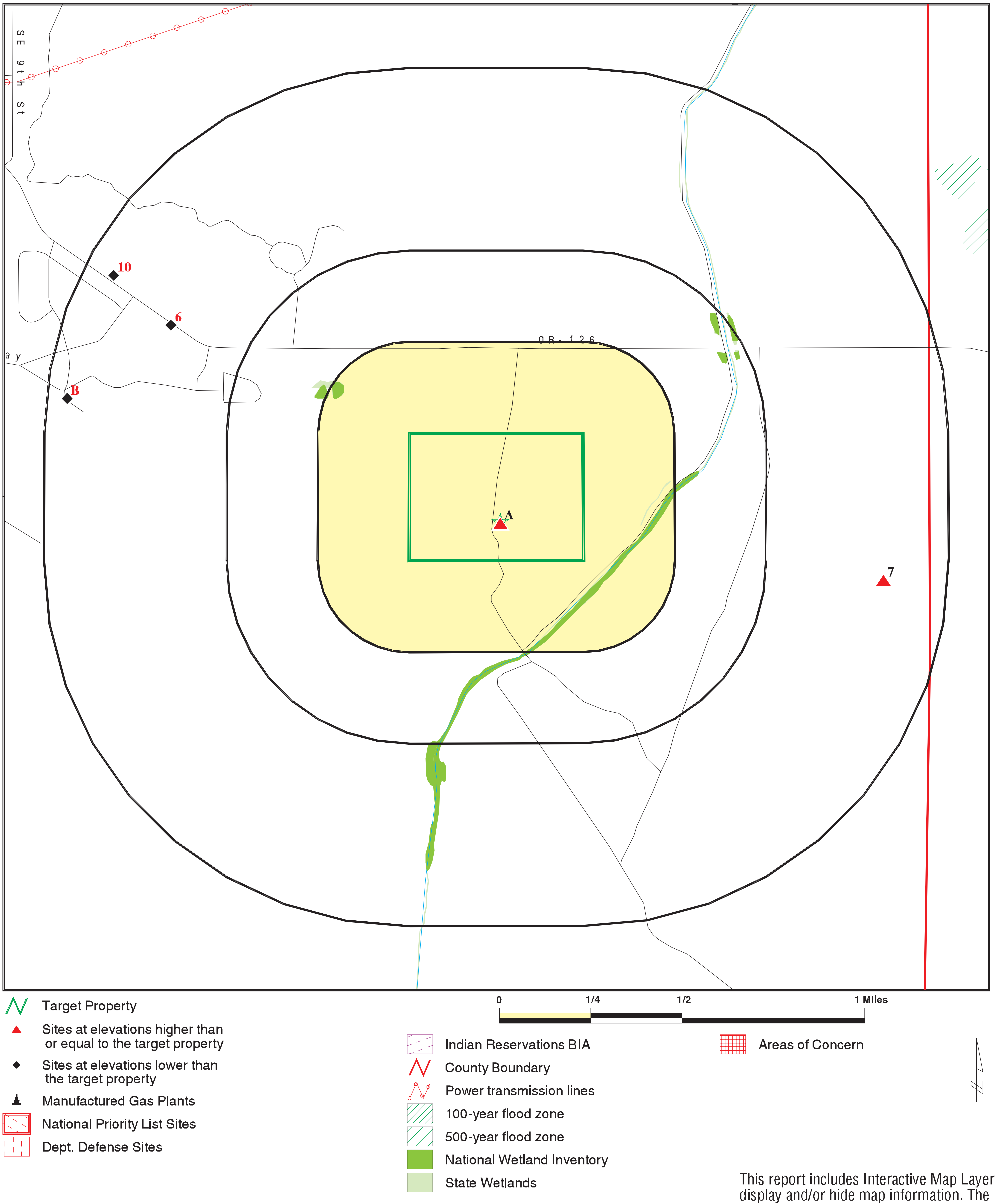
Lower Elevation	Address	Direction / Distance	Map ID	Page
DESCHUTES CO. PROPER Investigation: Suspect State ID Number: 4710 State ID Number: 5054	***2555 E HWY 126***	***WNW 1/2 - 1 (0.717 mi.)***	***6***	***9***
REDMOND MUNICIPAL AI Investigation: Suspect State ID Number: 5952	***1020-1050 SE SISTERS***	***WNW 1/2 - 1 (0.914 mi.)***	***B8***	***9***
REDMOND MUNICIPAL AI Investigation: Suspect State ID Number: 4103	1020 SE SISTERS AVE	WNW 1/2 - 1 (0.914 mi.)	B9	10
MAX MILLS FORMERLY O Investigation: No Further Action State ID Number: 3465	***HWY 126 (BTWN 27TH &***	***WNW 1/2 - 1 (0.918 mi.)***	***10***	***10***
DESCHUTES READY MIX Investigation: No Further Action State ID Number: 2637	***700 SW SISTERS AVE***	***WNW 1/2 - 1 (0.942 mi.)***	***B11***	***10***

Count: 0 records.

ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
		NO SITES FOUND			

OVERVIEW MAP - 5464928.2S

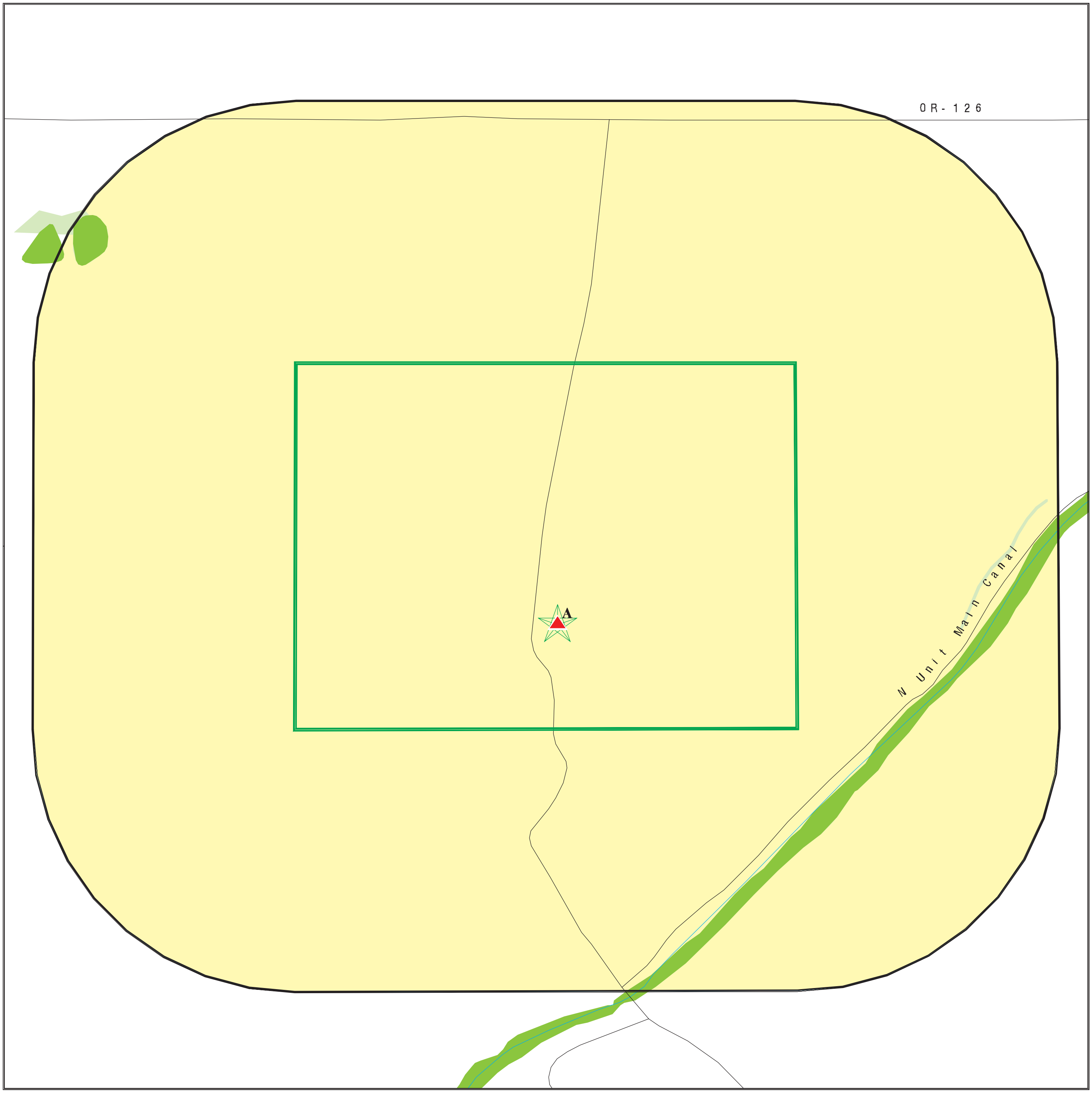


This report includes Interactive Map Layers to display and/or hide map information. The legend includes only those icons for the default map view.

SITE NAME: Redmond BIAK COUTES
ADDRESS: 2522 SE Jesse Butler Cir
Redmond OR 97756
LAT/LONG: 44.255065 / 121.131854

CLIENT: AECOM
CONTACT: Brittany Kirchmann
INQUIRY #: 5464928.2s
DATE: October 25, 2018 11:40 am

DETAIL MAP - 5464928.2S



0 1/8 1/4 1/2 Miles

- Target Property
- ▲ Sites at elevations higher than or equal to the target property
- ◆ Sites at elevations lower than the target property
- Manufactured Gas Plants
- Sensitive Receptors
- ▨ National Priority List Sites
- ▨ Dept. Defense Sites
- ▨ Indian Reservations BIA
- ▨ 100-year flood zone
- ▨ 500-year flood zone
- 🟩 National Wetland Inventory
- 🟩 State Wetlands
- ▦ Areas of Concern

This report includes Interactive Map Layers to display and/or hide map information. The legend includes only those icons for the default map view.

SITE NAME:	Redmond BIAK COUTES	CLIENT:	AECOM
ADDRESS:	2522 SE Jesse Butler Cir Redmond OR 97756	CONTACT:	Brittany Kirchmann
		INQUIRY #:	5464928.2s
LAT/LONG:	44.255065 / 121.131854	DATE:	October 25, 2018 11:42 am

MAP FINDINGS SUMMARY

Database	Search Distance (Miles)	Target Property	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
STANDARD ENVIRONMENTAL RECORDS								
Federal NPL site list								
NPL	1.000		0	0	0	0	NR	0
Proposed NPL	1.000		0	0	0	0	NR	0
NPL LIENS	TP		NR	NR	NR	NR	NR	0
Federal Delisted NPL site list								
Delisted NPL	1.000		0	0	0	0	NR	0
Federal CERCLIS list								
FEDERAL FACILITY	0.500		0	0	0	NR	NR	0
SEMS	0.500		0	0	0	NR	NR	0
Federal CERCLIS NFRAP site list								
SEMS-ARCHIVE	0.500		0	0	0	NR	NR	0
Federal RCRA CORRACTS facilities list								
CORRACTS	1.000		0	0	0	0	NR	0
Federal RCRA non-CORRACTS TSD facilities list								
RCRA-TSDF	0.500		0	0	0	NR	NR	0
Federal RCRA generators list								
RCRA-LQG	0.250		0	0	NR	NR	NR	0
RCRA-SQG	0.250		0	0	NR	NR	NR	0
RCRA-CESQG	0.250		0	0	NR	NR	NR	0
Federal institutional controls / engineering controls registries								
LUCIS	0.500		0	0	0	NR	NR	0
US ENG CONTROLS	0.500		0	0	0	NR	NR	0
US INST CONTROL	0.500		0	0	0	NR	NR	0
Federal ERNS list								
ERNS	TP		NR	NR	NR	NR	NR	0
State- and tribal - equivalent CERCLIS								
ECSI	1.000	1	0	0	0	6	NR	7
CRL	1.000		0	0	0	0	NR	0
State and tribal landfill and/or solid waste disposal site lists								
SWF/LF	0.500		0	0	0	NR	NR	0
State and tribal leaking storage tank lists								
LUST	0.500		0	0	0	NR	NR	0
INDIAN LUST	0.500		0	0	0	NR	NR	0
State and tribal registered storage tank lists								
FEMA UST	0.250		0	0	NR	NR	NR	0

MAP FINDINGS SUMMARY

Database	Search Distance (Miles)	Target Property	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
UST	0.250		0	0	NR	NR	NR	0
AST	0.250	1	0	0	NR	NR	NR	1
INDIAN UST	0.250		0	0	NR	NR	NR	0
State and tribal institutional control / engineering control registries								
ENG CONTROLS	0.500		0	0	0	NR	NR	0
INST CONTROL	0.500		0	0	0	NR	NR	0
State and tribal voluntary cleanup sites								
INDIAN VCP	0.500		0	0	0	NR	NR	0
VCP	0.500	1	0	0	0	NR	NR	1
State and tribal Brownfields sites								
BROWNFIELDS	0.500		0	0	0	NR	NR	0

ADDITIONAL ENVIRONMENTAL RECORDS

Database	Search Distance (Miles)	Target Property	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
Local Brownfield lists								
US BROWNFIELDS	0.500		0	0	0	NR	NR	0
Local Lists of Landfill / Solid Waste Disposal Sites								
HIST LF	0.500		0	0	0	NR	NR	0
SWRCY	0.500		0	0	0	NR	NR	0
INDIAN ODI	0.500		0	0	0	NR	NR	0
ODI	0.500		0	0	0	NR	NR	0
DEBRIS REGION 9	0.500		0	0	0	NR	NR	0
IHS OPEN DUMPS	0.500		0	0	0	NR	NR	0
Local Lists of Hazardous waste / Contaminated Sites								
US HIST CDL	TP		NR	NR	NR	NR	NR	0
AOCONCERN	1.000		0	0	0	0	NR	0
CDL	TP		NR	NR	NR	NR	NR	0
US CDL	TP		NR	NR	NR	NR	NR	0
Local Land Records								
LIENS 2	TP		NR	NR	NR	NR	NR	0
Records of Emergency Release Reports								
HMIRS	TP		NR	NR	NR	NR	NR	0
SPILLS	TP		NR	NR	NR	NR	NR	0
OR HAZMAT	TP	2	NR	NR	NR	NR	NR	2
SPILLS 90	TP		NR	NR	NR	NR	NR	0
Other Ascertainable Records								
RCRA NonGen / NLR	0.250		0	0	NR	NR	NR	0
FUDS	1.000		0	0	0	0	NR	0
DOD	1.000		0	0	0	0	NR	0

MAP FINDINGS SUMMARY

Database	Search Distance (Miles)	Target Property	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
SCRD DRYCLEANERS	0.500		0	0	0	NR	NR	0
US FIN ASSUR	TP		NR	NR	NR	NR	NR	0
EPA WATCH LIST	TP		NR	NR	NR	NR	NR	0
2020 COR ACTION	0.250		0	0	NR	NR	NR	0
TSCA	TP		NR	NR	NR	NR	NR	0
TRIS	TP		NR	NR	NR	NR	NR	0
SSTS	TP		NR	NR	NR	NR	NR	0
ROD	1.000		0	0	0	0	NR	0
RMP	TP		NR	NR	NR	NR	NR	0
RAATS	TP		NR	NR	NR	NR	NR	0
PRP	TP		NR	NR	NR	NR	NR	0
PADS	TP		NR	NR	NR	NR	NR	0
ICIS	TP		NR	NR	NR	NR	NR	0
FTTS	TP		NR	NR	NR	NR	NR	0
MLTS	TP		NR	NR	NR	NR	NR	0
COAL ASH DOE	TP		NR	NR	NR	NR	NR	0
COAL ASH EPA	0.500		0	0	0	NR	NR	0
PCB TRANSFORMER	TP		NR	NR	NR	NR	NR	0
RADINFO	TP		NR	NR	NR	NR	NR	0
HIST FTTS	TP		NR	NR	NR	NR	NR	0
DOT OPS	TP		NR	NR	NR	NR	NR	0
CONSENT	1.000		0	0	0	0	NR	0
INDIAN RESERV	1.000		0	0	0	0	NR	0
FUSRAP	1.000		0	0	0	0	NR	0
UMTRA	0.500		0	0	0	NR	NR	0
LEAD SMELTERS	TP		NR	NR	NR	NR	NR	0
US AIRS	TP		NR	NR	NR	NR	NR	0
US MINES	0.250		0	0	NR	NR	NR	0
ABANDONED MINES	0.250		0	0	NR	NR	NR	0
FINDS	TP		NR	NR	NR	NR	NR	0
ECHO	TP		NR	NR	NR	NR	NR	0
UXO	1.000		0	0	0	0	NR	0
DOCKET HWC	TP		NR	NR	NR	NR	NR	0
FUELS PROGRAM	0.250		0	0	NR	NR	NR	0
AIRS	TP		NR	NR	NR	NR	NR	0
COAL ASH	0.500		0	0	0	NR	NR	0
DRYCLEANERS	0.250		0	0	NR	NR	NR	0
Enforcement	TP		NR	NR	NR	NR	NR	0
Financial Assurance	TP		NR	NR	NR	NR	NR	0
HSIS	TP	1	NR	NR	NR	NR	NR	1
MANIFEST	0.250		0	0	NR	NR	NR	0
NPDES	TP		NR	NR	NR	NR	NR	0
UIC	TP	1	NR	NR	NR	NR	NR	1

EDR HIGH RISK HISTORICAL RECORDS

EDR Exclusive Records

Database	Search Distance (Miles)	Target Property	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
EDR MGP	1.000		0	0	0	0	NR	0
EDR Hist Auto	0.125		0	NR	NR	NR	NR	0
EDR Hist Cleaner	0.125		0	NR	NR	NR	NR	0

MAP FINDINGS SUMMARY

Database	Search Distance (Miles)	Target Property	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
EDR RECOVERED GOVERNMENT ARCHIVES								
Exclusive Recovered Govt. Archives								
RGA HWS	TP	1	NR	NR	NR	NR	NR	1
RGA LF	TP		NR	NR	NR	NR	NR	0
RGA LUST	TP		NR	NR	NR	NR	NR	0
- Totals --		8	0	0	0	6	0	14

NOTES:

TP = Target Property

NR = Not Requested at this Search Distance

Sites may be listed in more than one database

A1 **Target** **Property**	**2522 SE JESSE BUTLER CIR** **REDMOND, OR 97756**	**OR HAZMAT**	**S116497164** **N/A**

Actual:
3069 ft.

Click here for full text details

OR HAZMAT
Facility Id: 1440852

A2 **Target** **Property**	**ROBERTS FIELD TERMINAL EXPANSION** **2522 SE JESSE BUTLER CIRCLE # 17** **REDMOND, OR**	**RGA HWS**	**S115337358** **N/A**

Actual:
3069 ft.

Click here for full text details

A3 **Target** **Property**	**REDMOND MUNICIPAL AIRPORT -ETHYLENE GLYCOL RELEASE** **2522 SE JESSE BUTLER CIRCLE #17** **REDMOND, OR 97756**	**ECSI** **VCP** **UIC**	**S111242923** **N/A**

Actual:
3069 ft.

Click here for full text details

ECSI
State ID Number: 5121
Investigation: No Further Action

VCP
ECS Site ID: 5121

UIC
UIC Number: 12415
Facility Status: Applied for permit

A4 **Target** **Property**	**REDMOND CITY OF** **2522 SE JESSE BUTLER CIR 17** **REDMOND, OR 97756**	**AST** **HSIS**	**S105745181** **N/A**

Actual:
3069 ft.

Click here for full text details

AST
Facility Id: 033518

HSIS
Facility Id: 033518

A5
Target
Property
2522 SE JESSE BUTLER CIR
REDMOND, OR 97756
OR HAZMAT **S117403350**
N/A

Actual:
3069 ft.

Click here for full text details

OR HAZMAT
Facility Id: 1443274

6
WNW
1/2-1
0.717 mi.
3786 ft.
DESCHUTES CO. PROPERTY - TL 103
2555 E HWY 126
REDMOND, OR 97756
ECSI **S108169760**
BROWNFIELDS **N/A**

Relative:
Lower

Click here for full text details

ECSI
State ID Number: 4710
State ID Number: 5054
Investigation: Suspect

BROWNFIELDS
envid: 5054
Status: Site Investigation recommended (SI)

7
East
1/2-1
0.823 mi.
4344 ft.
BIAK TRAINING CENTER RANGE 2

REDMOND, OR 97756
ECSI **S109346110**
N/A

Relative:
Higher

Click here for full text details

ECSI
State ID Number: 5050
State ID Number: 5051
Investigation: No Further Action

B8
WNW
1/2-1
0.914 mi.
4824 ft.
REDMOND MUNICIPAL AIRPORT - HANGER 10 AREA
1020-1050 SE SISTERS AVE
REDMOND, OR 97756
ECSI **S117684800**
VCP **N/A**

Relative:
Lower

Click here for full text details

ECSI
State ID Number: 5952
Investigation: Suspect

VCP
ECS Site ID: 5952

B9
WNW
1/2-1
0.914 mi.
4824 ft.

Relative:
Lower

REDMOND MUNICIPAL AIRPORT-BUTLER FARM AIR SERVICE
1020 SE SISTERS AVE
REDMOND, OR 97756

ECSI

S106980909
N/A

Click here for full text details

ECSI
State ID Number: 4103
Investigation: Suspect

10
WNW
1/2-1
0.918 mi.
4847 ft.

Relative:
Lower

MAX MILLS FORMERLY OWNED PROPERTY
HWY 126 (BTWN 27TH & 33RD)
REDMOND, OR 97756

ECSI
VCP

S106497209
N/A

Click here for full text details

ECSI
State ID Number: 3465
Investigation: No Further Action

VCP
ECS Site ID: 3465

B11
WNW
1/2-1
0.942 mi.
4973 ft.

Relative:
Lower

DESCHUTES READY MIX - REDMOND
700 SW SISTERS AVE
REDMOND, OR 97756

ECSI
VCP
UIC

S104550503
N/A

Click here for full text details

ECSI
State ID Number: 2637
Investigation: No Further Action

VCP
ECS Site ID: 2637

UIC
UIC Number: 13375
Facility Status: Not Registered

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

St	Acronym	Full Name	Government Agency	Gov Date	Arvl. Date	Active Date
OR	AIRS	Oregon Title V Facility Listing	Department of Environmental Quality	07/03/2018	07/10/2018	08/17/2018
OR	AOC COL	Columbia Slough	City of Portland Environmental Services	08/10/2005	05/17/2006	06/16/2006
OR	AOC MU	East Multnomah County Area	City of Portland Environmental Services		10/07/2002	10/22/2002
OR	AST	Aboveground Storage Tanks	Office of State Fire Marshal	09/05/2017	11/16/2017	01/09/2018
OR	BROWNFIELDS	Brownfields Projects	Department of Environmental Quality	08/01/2018	08/10/2018	09/24/2018
OR	CDL	Uninhabitable Drug Lab Properties	Department of Consumer & Business Services	09/21/2018	09/25/2018	10/22/2018
OR	CDL 2	Clandestine Drug Lab Site Listing	Oregon State Police	07/01/2018	08/01/2018	08/15/2018
OR	COAL ASH	Coal Ash Disposal Sites Listing	Department of Environmental Quality	12/31/2017	03/16/2018	05/15/2018
OR	CRL	Confirmed Release List and Inventory	Department of Environmental Quality	08/01/2018	08/10/2018	09/24/2018
OR	DRYCLEANERS	Drycleaning Facilities	Department of Environmental Quality	07/27/2018	07/31/2018	08/15/2018
OR	ECSI	Environmental Cleanup Site Information System	Department of Environmental Quality	10/01/2018	10/03/2018	10/23/2018
OR	ENF	Enforcement Action Listing	Department of Environmental Quality	09/18/2018	09/19/2018	10/23/2018
OR	ENG CONTROLS	Engineering Controls Recorded at ESCI Sites	Department of Environmental Quality	10/01/2018	10/03/2018	10/23/2018
OR	Financial Assurance 1	Financial Assurance Information Listing	Department of Environmental Quality	05/21/2018	06/21/2018	07/23/2018
OR	Financial Assurance 2	Financial Assurance Information Listing	Department of Environmental Quality	08/20/2018	08/21/2018	09/24/2018
OR	HAZMAT	Hazmat/Incidents	State Fire Marshal’s Office	07/01/2018	08/01/2018	08/15/2018
OR	HIST LF	Old Closed SW Disposal Sites	Department of Environmental Quality	04/01/2000	07/08/2003	07/18/2003
OR	HSIS	Hazardous Substance Information Survey	State Fire Marshal’s Office	05/03/2018	05/03/2018	06/07/2018
OR	INST CONTROL	Institutional Controls Recorded at ESCI Sites	Department of Environmental Quality	10/01/2018	10/03/2018	10/23/2018
OR	LUST	Leaking Underground Storage Tank Database	Department of Environmental Quality	07/02/2018	08/10/2018	09/24/2018
OR	NPDES	Wastewater Permits Database	Department of Environmental Quality	09/20/2018	09/20/2018	10/22/2018
OR	OR MANIFEST	Manifest Information	Department of Environmental Quality	12/31/2017	08/06/2018	08/15/2018
OR	RGA HWS	Recovered Government Archive State Hazardous Waste Facilitie	Department of Environmental Quality		07/01/2013	01/03/2014
OR	RGA LF	Recovered Government Archive Solid Waste Facilities List	Department of Environmental Quality		07/01/2013	01/13/2014
OR	RGA LUST	Recovered Government Archive Leaking Underground Storage Tan	Department of Environmental Quality		07/01/2013	12/27/2013
OR	SPILLS	Spill Data	Department of Environmental Quality	10/01/2018	10/02/2018	10/23/2018
OR	SPILLS 90	SPILLS90 data from FirstSearch	FirstSearch	05/01/2006	01/03/2013	02/22/2013
OR	SWF/LF	Solid Waste Facilities List	Department of Environmental Quality	07/16/2018	07/20/2018	08/20/2018
OR	SWRCY	Recycling Facility Location Listing	Department of Environmental Quality	08/28/2018	08/29/2018	09/24/2018
OR	UIC	Underground Injection Control Program Database	Department of Environmental Quality	09/25/2018	09/27/2018	10/23/2018
OR	UST	Underground Storage Tank Database	Department of Environmental Quality	07/02/2018	08/10/2018	09/24/2018
OR	VCS	Voluntary Cleanup Program Sites	DEQ	06/29/2018	07/03/2018	07/23/2018
US	2020 COR ACTION	2020 Corrective Action Program List	Environmental Protection Agency	09/30/2017	05/08/2018	07/20/2018
US	ABANDONED MINES	Abandoned Mines	Department of Interior	09/10/2018	09/11/2018	09/14/2018
US	BRS	Biennial Reporting System	EPA/NTIS	12/31/2015	02/22/2017	09/28/2017
US	COAL ASH DOE	Steam-Electric Plant Operation Data	Department of Energy	12/31/2005	08/07/2009	10/22/2009
US	COAL ASH EPA	Coal Combustion Residues Surface Impoundments List	Environmental Protection Agency	07/01/2014	09/10/2014	10/20/2014
US	CONSENT	Superfund (CERCLA) Consent Decrees	Department of Justice, Consent Decree Library	06/30/2018	07/17/2018	10/05/2018
US	CORRACTS	Corrective Action Report	EPA	03/01/2018	03/28/2018	06/22/2018
US	DEBRIS REGION 9	Torres Martinez Reservation Illegal Dump Site Locations	EPA, Region 9	01/12/2009	05/07/2009	09/21/2009
US	DOCKET HWC	Hazardous Waste Compliance Docket Listing	Environmental Protection Agency	05/31/2018	07/26/2018	10/05/2018
US	DOD	Department of Defense Sites	USGS	12/31/2005	11/10/2006	01/11/2007
US	DOT OPS	Incident and Accident Data	Department of Transporation, Office of Pipeli	07/31/2012	08/07/2012	09/18/2012
US	Delisted NPL	National Priority List Deletions	EPA	07/17/2018	08/09/2018	09/07/2018
US	ECHO	Enforcement & Compliance History Information	Environmental Protection Agency	09/02/2018	09/05/2018	09/14/2018
US	EDR Hist Auto	EDR Exclusive Historical Auto Stations	EDR, Inc.			
US	EDR Hist Cleaner	EDR Exclusive Historical Cleaners	EDR, Inc.			

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

St	Acronym	Full Name	Government Agency	Gov Date	Arvl. Date	Active Date
US	EDR MGP	EDR Proprietary Manufactured Gas Plants	EDR, Inc.			
US	EPA WATCH LIST	EPA WATCH LIST	Environmental Protection Agency	08/30/2013	03/21/2014	06/17/2014
US	ERNS	Emergency Response Notification System	National Response Center, United States Coast	06/18/2018	06/27/2018	09/14/2018
US	FEDERAL FACILITY	Federal Facility Site Information listing	Environmental Protection Agency	11/07/2016	01/05/2017	04/07/2017
US	FEDLAND	Federal and Indian Lands	U.S. Geological Survey	12/31/2005	02/06/2006	01/11/2007
US	FEMA UST	Underground Storage Tank Listing	FEMA	05/15/2017	05/30/2017	10/13/2017
US	FINDS	Facility Index System/Facility Registry System	EPA	08/07/2018	09/05/2018	10/05/2018
US	FTTS	FIFRA/ TSCA Tracking System - FIFRA (Federal Insecticide, Fu	EPA/Office of Prevention, Pesticides and Toxi	04/09/2009	04/16/2009	05/11/2009
US	FTTS INSP	FIFRA/ TSCA Tracking System - FIFRA (Federal Insecticide, Fu	EPA	04/09/2009	04/16/2009	05/11/2009
US	FUDS	Formerly Used Defense Sites	U.S. Army Corps of Engineers	01/31/2015	07/08/2015	10/13/2015
US	FUELS PROGRAM	EPA Fuels Program Registered Listing	EPA	08/22/2018	08/22/2018	10/05/2018
US	FUSRAP	Formerly Utilized Sites Remedial Action Program	Department of Energy	08/08/2017	09/11/2018	09/14/2018
US	HIST FTTS	FIFRA/TSCA Tracking System Administrative Case Listing	Environmental Protection Agency	10/19/2006	03/01/2007	04/10/2007
US	HIST FTTS INSP	FIFRA/TSCA Tracking System Inspection & Enforcement Case Lis	Environmental Protection Agency	10/19/2006	03/01/2007	04/10/2007
US	HMIRS	Hazardous Materials Information Reporting System	U.S. Department of Transportation	03/26/2018	03/27/2018	06/08/2018
US	ICIS	Integrated Compliance Information System	Environmental Protection Agency	11/18/2016	11/23/2016	02/10/2017
US	IHS OPEN DUMPS	Open Dumps on Indian Land	Department of Health & Human Serivces, Indian	04/01/2014	08/06/2014	01/29/2015
US	INDIAN LUST R1	Leaking Underground Storage Tanks on Indian Land	EPA Region 1	04/13/2018	05/18/2018	07/20/2018
US	INDIAN LUST R10	Leaking Underground Storage Tanks on Indian Land	EPA Region 10	04/12/2018	05/18/2018	07/20/2018
US	INDIAN LUST R4	Leaking Underground Storage Tanks on Indian Land	EPA Region 4	05/08/2018	05/18/2018	07/20/2018
US	INDIAN LUST R5	Leaking Underground Storage Tanks on Indian Land	EPA, Region 5	04/12/2018	05/18/2018	07/20/2018
US	INDIAN LUST R6	Leaking Underground Storage Tanks on Indian Land	EPA Region 6	04/01/2018	05/18/2018	07/20/2018
US	INDIAN LUST R7	Leaking Underground Storage Tanks on Indian Land	EPA Region 7	04/24/2018	05/18/2018	07/20/2018
US	INDIAN LUST R8	Leaking Underground Storage Tanks on Indian Land	EPA Region 8	04/25/2018	05/18/2018	07/20/2018
US	INDIAN LUST R9	Leaking Underground Storage Tanks on Indian Land	Environmental Protection Agency	04/10/2018	05/18/2018	07/20/2018
US	INDIAN ODI	Report on the Status of Open Dumps on Indian Lands	Environmental Protection Agency	12/31/1998	12/03/2007	01/24/2008
US	INDIAN RESERV	Indian Reservations	USGS	12/31/2014	07/14/2015	01/10/2017
US	INDIAN UST R1	Underground Storage Tanks on Indian Land	EPA, Region 1	04/13/2018	05/18/2018	07/20/2018
US	INDIAN UST R10	Underground Storage Tanks on Indian Land	EPA Region 10	04/12/2018	05/18/2018	07/20/2018
US	INDIAN UST R4	Underground Storage Tanks on Indian Land	EPA Region 4	05/08/2018	05/18/2018	07/20/2018
US	INDIAN UST R5	Underground Storage Tanks on Indian Land	EPA Region 5	04/12/2018	05/18/2018	07/20/2018
US	INDIAN UST R6	Underground Storage Tanks on Indian Land	EPA Region 6	04/01/2018	05/18/2018	07/20/2018
US	INDIAN UST R7	Underground Storage Tanks on Indian Land	EPA Region 7	04/24/2018	05/18/2018	07/20/2018
US	INDIAN UST R8	Underground Storage Tanks on Indian Land	EPA Region 8	04/25/2018	05/18/2018	07/20/2018
US	INDIAN UST R9	Underground Storage Tanks on Indian Land	EPA Region 9	04/10/2018	05/18/2018	07/20/2018
US	INDIAN VCP R1	Voluntary Cleanup Priority Listing	EPA, Region 1	07/27/2015	09/29/2015	02/18/2016
US	INDIAN VCP R7	Voluntary Cleanup Priority Lisitng	EPA, Region 7	03/20/2008	04/22/2008	05/19/2008
US	LEAD SMELTER 1	Lead Smelter Sites	Environmental Protection Agency	07/17/2018	08/09/2018	10/05/2018
US	LEAD SMELTER 2	Lead Smelter Sites	American Journal of Public Health	04/05/2001	10/27/2010	12/02/2010
US	LIENS 2	CERCLA Lien Information	Environmental Protection Agency	07/17/2018	08/09/2018	10/05/2018
US	LUCIS	Land Use Control Information System	Department of the Navy	05/14/2018	05/18/2018	07/20/2018
US	MLTS	Material Licensing Tracking System	Nuclear Regulatory Commission	08/30/2016	09/08/2016	10/21/2016
US	NPL	National Priority List	EPA	07/17/2018	08/09/2018	09/07/2018
US	NPL LIENS	Federal Superfund Liens	EPA	10/15/1991	02/02/1994	03/30/1994
US	ODI	Open Dump Inventory	Environmental Protection Agency	06/30/1985	08/09/2004	09/17/2004
US	PADS	PCB Activity Database System	EPA	06/01/2017	06/09/2017	10/13/2017
US	PCB TRANSFORMER	PCB Transformer Registration Database	Environmental Protection Agency	05/24/2017	11/30/2017	12/15/2017

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

St	Acronym	Full Name	Government Agency	Gov Date	Arvl. Date	Active Date
US	PRP	Potentially Responsible Parties	EPA	10/25/2013	10/17/2014	10/20/2014
US	Proposed NPL	Proposed National Priority List Sites	EPA	07/17/2018	08/09/2018	09/07/2018
US	RAATS	RCRA Administrative Action Tracking System	EPA	04/17/1995	07/03/1995	08/07/1995
US	RADINFO	Radiation Information Database	Environmental Protection Agency	07/02/2018	07/05/2018	10/05/2018
US	RCRA NonGen / NLR	RCRA - Non Generators / No Longer Regulated	Environmental Protection Agency	03/01/2018	03/28/2018	06/22/2018
US	RCRA-CESQG	RCRA - Conditionally Exempt Small Quantity Generators	Environmental Protection Agency	03/01/2018	03/28/2018	06/22/2018
US	RCRA-LQG	RCRA - Large Quantity Generators	Environmental Protection Agency	03/01/2018	03/28/2018	06/22/2018
US	RCRA-SQG	RCRA - Small Quantity Generators	Environmental Protection Agency	03/01/2018	03/28/2018	06/22/2018
US	RCRA-TSDF	RCRA - Treatment, Storage and Disposal	Environmental Protection Agency	03/01/2018	03/28/2018	06/22/2018
US	RMP	Risk Management Plans	Environmental Protection Agency	08/01/2018	08/22/2018	10/05/2018
US	ROD	Records Of Decision	EPA	07/17/2018	08/09/2018	10/05/2018
US	SCRD DRYCLEANERS	State Coalition for Remediation of Drycleaners Listing	Environmental Protection Agency	01/01/2017	02/03/2017	04/07/2017
US	SEMS	Superfund Enterprise Management System	EPA	07/17/2018	08/09/2018	09/07/2018
US	SEMS-ARCHIVE	Superfund Enterprise Management System Archive	EPA	07/17/2018	08/09/2018	09/07/2018
US	SSTS	Section 7 Tracking Systems	EPA	12/31/2009	12/10/2010	02/25/2011
US	TRIS	Toxic Chemical Release Inventory System	EPA	12/31/2016	01/10/2018	01/12/2018
US	TSCA	Toxic Substances Control Act	EPA	12/31/2016	06/21/2017	01/05/2018
US	UMTRA	Uranium Mill Tailings Sites	Department of Energy	06/23/2017	10/11/2017	11/03/2017
US	US AIRS (AFS)	Aerometric Information Retrieval System Facility Subsystem (	EPA	10/12/2016	10/26/2016	02/03/2017
US	US AIRS MINOR	Air Facility System Data	EPA	10/12/2016	10/26/2016	02/03/2017
US	US BROWNFIELDS	A Listing of Brownfields Sites	Environmental Protection Agency	06/18/2018	06/20/2018	09/14/2018
US	US CDL	Clandestine Drug Labs	Drug Enforcement Administration	05/18/2018	06/20/2018	09/14/2018
US	US ENG CONTROLS	Engineering Controls Sites List	Environmental Protection Agency	07/31/2018	08/28/2018	09/14/2018
US	US FIN ASSUR	Financial Assurance Information	Environmental Protection Agency	05/31/2018	06/27/2018	10/05/2018
US	US HIST CDL	National Clandestine Laboratory Register	Drug Enforcement Administration	05/18/2018	06/20/2018	09/14/2018
US	US INST CONTROL	Sites with Institutional Controls	Environmental Protection Agency	07/31/2018	08/28/2018	09/14/2018
US	US MINES	Mines Master Index File	Department of Labor, Mine Safety and Health A	08/01/2018	08/29/2018	10/05/2018
US	US MINES 2	Ferrous and Nonferrous Metal Mines Database Listing	USGS	12/05/2005	02/29/2008	04/18/2008
US	US MINES 3	Active Mines & Mineral Plants Database Listing	USGS	04/14/2011	06/08/2011	09/13/2011
US	UXO	Unexploded Ordnance Sites	Department of Defense	09/30/2017	06/19/2018	09/14/2018
NY	NY MANIFEST	Facility and Manifest Data	Department of Environmental Conservation	07/01/2018	08/01/2018	08/31/2018
WI	WI MANIFEST	Manifest Information	Department of Natural Resources	12/31/2017	06/15/2018	07/09/2018
US	AHA Hospitals	Sensitive Receptor: AHA Hospitals	American Hospital Association, Inc.			
US	Medical Centers	Sensitive Receptor: Medical Centers	Centers for Medicare & Medicaid Services			
US	Nursing Homes	Sensitive Receptor: Nursing Homes	National Institutes of Health			
US	Public Schools	Sensitive Receptor: Public Schools	National Center for Education Statistics			
US	Private Schools	Sensitive Receptor: Private Schools	National Center for Education Statistics			
OR	Daycare Centers	Sensitive Receptor: Child Care Listings	Employment Department			

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

St	Acronym	Full Name	Government Agency	Gov Date	Arvl. Date	Active Date
US	Flood Zones	100-year and 500-year flood zones	Emergency Management Agency (FEMA)			
US	NWI	National Wetlands Inventory	U.S. Fish and Wildlife Service			
OR	State Wetlands	Wetlands Inventory Data	Oregon Geospatial Enterprise Office			
US	Topographic Map		U.S. Geological Survey			
US	Oil/Gas Pipelines		PennWell Corporation			
US	Electric Power Transmission Line Data		PennWell Corporation			

STREET AND ADDRESS INFORMATION

GEOCHECK ®- PHYSICAL SETTING SOURCE ADDENDUM

TARGET PROPERTY ADDRESS

REDMOND BIAK COUTES
2522 SE JESSE BUTLER CIR
REDMOND, OR 97756

TARGET PROPERTY COORDINATES

Latitude (North):	44.255065 - 44˚ 15’ 18.23’’
Longitude (West):	121.131854 - 121˚ 7’ 54.67’’
Universal Tranverse Mercator:	Zone 10
UTM X (Meters):	649138.9
UTM Y (Meters):	4901683.5
Elevation:	3069 ft. above sea level

USGS TOPOGRAPHIC MAP

Target Property Map:	6067500 REDMOND, OR
Version Date:	2014
Northeast Map:	6067530 O’NEIL, OR
Version Date:	2014
Southeast Map:	6067496 POWELL BUTTE, OR
Version Date:	2014
Southwest Map:	6067448 FORKED HORN BUTTE, OR
Version Date:	2014

EDR’s GeoCheck Physical Setting Source Addendum is provided to assist the environmental professional in forming an opinion about the impact of potential contaminant migration.

Assessment of the impact of contaminant migration generally has two principle investigative components:

1. Groundwater flow direction, and
2. Groundwater flow velocity.

Groundwater flow direction may be impacted by surface topography, hydrology, hydrogeology, characteristics of the soil, and nearby wells. Groundwater flow velocity is generally impacted by the nature of the geologic strata.

GEOCHECK® - PHYSICAL SETTING SOURCE SUMMARY

GROUNDWATER FLOW DIRECTION INFORMATION

Groundwater flow direction for a particular site is best determined by a qualified environmental professional using site-specific well data. If such data is not reasonably ascertainable, it may be necessary to rely on other sources of information, such as surface topographic information, hydrologic information, hydrogeologic data collected on nearby properties, and regional groundwater flow information (from deep aquifers).

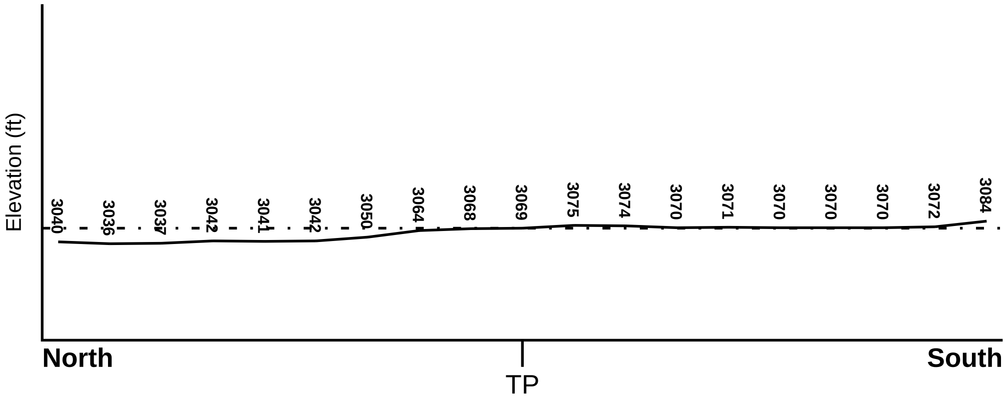
TOPOGRAPHIC INFORMATION

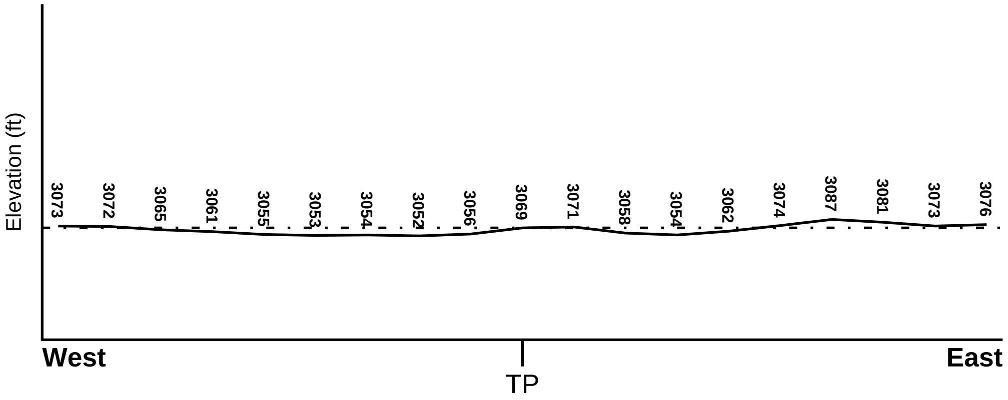
Surface topography may be indicative of the direction of surficial groundwater flow. This information can be used to assist the environmental professional in forming an opinion about the impact of nearby contaminated properties or, should contamination exist on the target property, what downgradient sites might be impacted.

TARGET PROPERTY TOPOGRAPHY

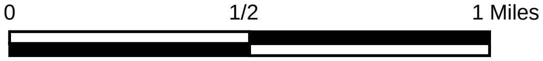
General Topographic Gradient: General North

SURROUNDING TOPOGRAPHY: ELEVATION PROFILES





Target Property Elevation: 3069 ft.



Source: Topography has been determined from the USGS 7.5' Digital Elevation Model and should be evaluated on a relative (not an absolute) basis. Relative elevation information between sites of close proximity should be field verified.

GEOCHECK® - PHYSICAL SETTING SOURCE SUMMARY

HYDROLOGIC INFORMATION

Surface water can act as a hydrologic barrier to groundwater flow. Such hydrologic information can be used to assist the environmental professional in forming an opinion about the impact of nearby contaminated properties or, should contamination exist on the target property, what downgradient sites might be impacted.

Refer to the Physical Setting Source Map following this summary for hydrologic information (major waterways and bodies of water).

FEMA FLOOD ZONE

Flood Plain Panel at Target Property	FEMA Source Type
41017C0325E	FEMA FIRM Flood data

Additional Panels in search area:	FEMA Source Type
41017C0350E	FEMA FIRM Flood data
41017C0150C	FEMA Q3 Flood data
41017C0525E	FEMA FIRM Flood data

NATIONAL WETLAND INVENTORY

NWI Quad at Target Property	NWI Electronic Data Coverage
REDMOND	YES - refer to the Overview Map and Detail Map

HYDROGEOLOGIC INFORMATION

Hydrogeologic information obtained by installation of wells on a specific site can often be an indicator of groundwater flow direction in the immediate area. Such hydrogeologic information can be used to assist the environmental professional in forming an opinion about the impact of nearby contaminated properties or, should contamination exist on the target property, what downgradient sites might be impacted.

AQUIFLOW®

Search Radius: 1.000 Mile.

EDR has developed the AQUIFLOW Information System to provide data on the general direction of groundwater flow at specific points. EDR has reviewed reports submitted by environmental professionals to regulatory authorities at select sites and has extracted the date of the report, groundwater flow direction as determined hydrogeologically, and the depth to water table.

MAP ID	LOCATION FROM TP	GENERAL DIRECTION GROUNDWATER FLOW
Not Reported		

GROUNDWATER FLOW VELOCITY INFORMATION

Groundwater flow velocity information for a particular site is best determined by a qualified environmental professional using site specific geologic and soil strata data. If such data are not reasonably ascertainable, it may be necessary to rely on other sources of information, including geologic age identification, rock stratigraphic unit and soil characteristics data collected on nearby properties and regional soil information. In general, contaminant plumes move more quickly through sandy-gravelly types of soils than silty-clayey types of soils.

GEOLOGIC INFORMATION IN GENERAL AREA OF TARGET PROPERTY

Geologic information can be used by the environmental professional in forming an opinion about the relative speed at which contaminant migration may be occurring.

ROCK STRATIGRAPHIC UNIT

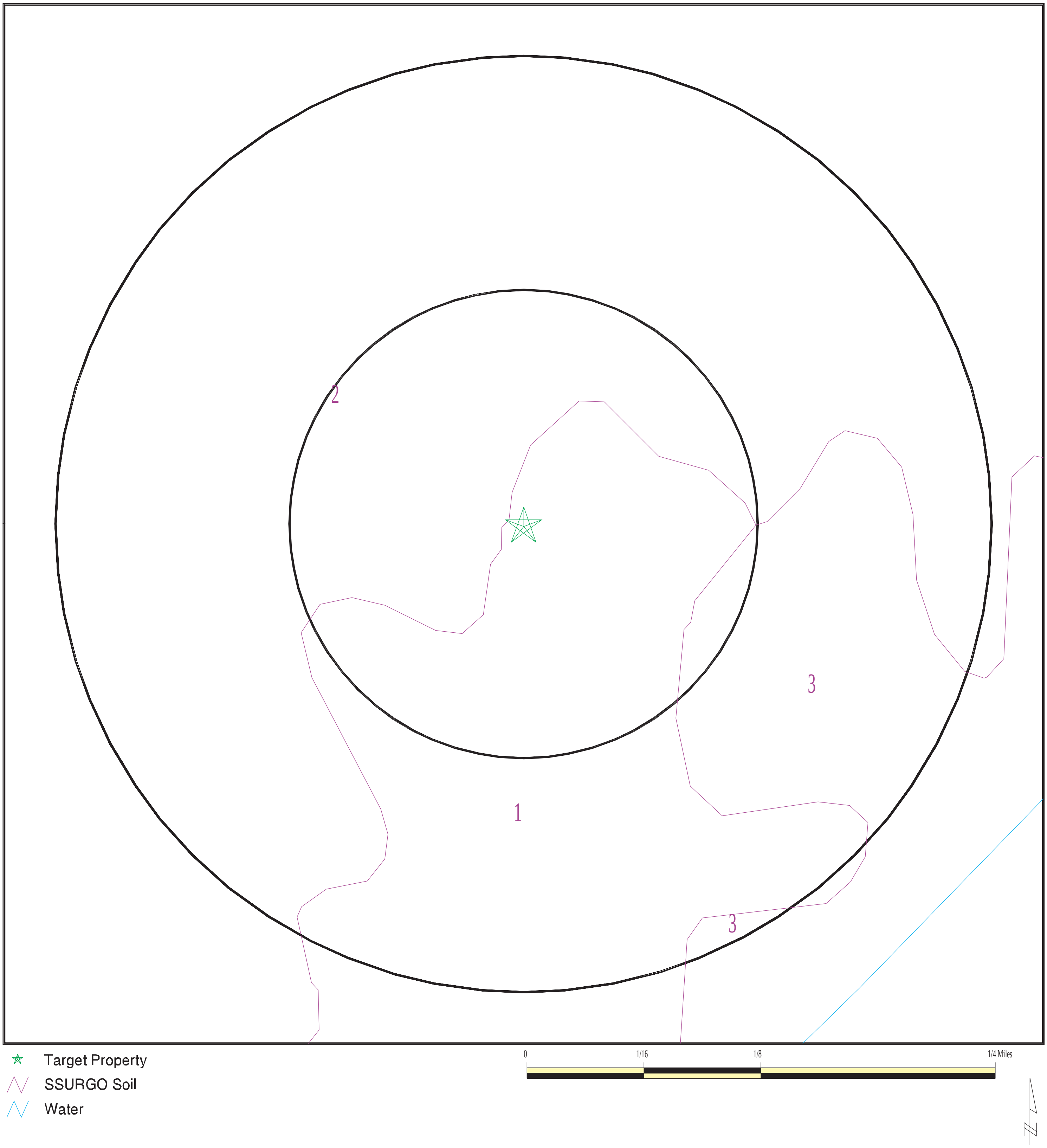
Era: Cenozoic
System: Quaternary
Series: Quaternary volcanic rocks
Code: Qv *(decoded above as Era, System & Series)*

GEOLOGIC AGE IDENTIFICATION

Category: Volcanic Rocks

Geologic Age and Rock Stratigraphic Unit Source: P.G. Schruben, R.E. Arndt and W.J. Bawiec, Geology of the Conterminous U.S. at 1:2,500,000 Scale - a digital representation of the 1974 P.B. King and H.M. Beikman Map, USGS Digital Data Series DDS - 11 (1994).

SSURGO SOIL MAP - 5464928.2s



SITE NAME: Redmond BIAK COUTES
ADDRESS: 2522 SE Jesse Butler Cir
Redmond OR 97756
LAT/LONG: 44.255065 / 121.131854

CLIENT: AECOM
CONTACT: Brittany Kirchmann
INQUIRY #: 5464928.2s
DATE: October 25, 2018 11:42 am

DOMINANT SOIL COMPOSITION IN GENERAL AREA OF TARGET PROPERTY

The U.S. Department of Agriculture’s (USDA) Soil Conservation Service (SCS) leads the National Cooperative Soil Survey (NCSS) and is responsible for collecting, storing, maintaining and distributing soil survey information for privately owned lands in the United States. A soil map in a soil survey is a representation of soil patterns in a landscape. The following information is based on Soil Conservation Service SSURGO data.

Soil Map ID: 1

Soil Component Name:	Stukel
Soil Surface Texture:	sandy loam
Hydrologic Group:	Class C - Slow infiltration rates. Soils with layers impeding downward movement of water, or soils with moderately fine or fine textures.
Soil Drainage Class:	Well drained
Hydric Status: Not hydric	
Corrosion Potential - Uncoated Steel:	Moderate
Depth to Bedrock Min:	> 0 inches
Depth to Watertable Min:	> 0 inches

Soil Layer Information

	Boundary			Classification		Saturated hydraulic conductivity micro m/sec	
Layer	**Upper**	**Lower**	**Soil Texture Class**	**AASHTO Group**	**Unified Soil**		**Soil Reaction (pH)**
1	0 inches	3 inches	sandy loam	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:
2	3 inches	11 inches	cobbly sandy loam	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:
3	11 inches	18 inches	gravelly sandy loam	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:

Soil Layer Information							
	Boundary			Classification		Saturated hydraulic conductivity micro m/sec	Soil Reaction (pH)
Layer	Upper	Lower	Soil Texture Class	AASHTO Group	Unified Soil		
4	18 inches	27 inches	unweathered bedrock	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:

Soil Map ID: 2

Soil Component Name: Deschutes

Soil Surface Texture: sandy loam

Hydrologic Group: Class B - Moderate infiltration rates. Deep and moderately deep, moderately well and well drained soils with moderately coarse textures.

Soil Drainage Class: Well drained

Hydric Status: Not hydric

Corrosion Potential - Uncoated Steel: Moderate

Depth to Bedrock Min: > 46 inches

Depth to Watertable Min: > 0 inches

Soil Layer Information							
	Boundary			Classification		Saturated hydraulic conductivity micro m/sec	Soil Reaction (pH)
Layer	Upper	Lower	Soil Texture Class	AASHTO Group	Unified Soil		
1	0 inches	7 inches	sandy loam	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:
2	7 inches	16 inches	sandy loam	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:

Soil Layer Information							
	Boundary			Classification		Saturated hydraulic conductivity micro m/sec	Soil Reaction (pH)
Layer	Upper	Lower	Soil Texture Class	AASHTO Group	Unified Soil		
3	16 inches	31 inches	sandy loam	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:
4	31 inches	40 inches	unweathered bedrock	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:

Soil Map ID: 3

Soil Component Name:	Redmond
Soil Surface Texture:	sandy loam
Hydrologic Group:	Class C - Slow infiltration rates. Soils with layers impeding downward movement of water, or soils with moderately fine or fine textures.
Soil Drainage Class:	Well drained

Hydric Status: Not hydric

Corrosion Potential - Uncoated Steel:	High
Depth to Bedrock Min:	> 53 inches
Depth to Watertable Min:	> 0 inches

Soil Layer Information							
	Boundary			Classification		Saturated hydraulic conductivity micro m/sec	Soil Reaction (pH)
Layer	Upper	Lower	Soil Texture Class	AASHTO Group	Unified Soil		
1	0 inches	11 inches	sandy loam	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:

Soil Layer Information

	Boundary			Classification			
Layer	**Upper**	**Lower**	**Soil Texture Class**	**AASHTO Group**	**Unified Soil**	**Saturated hydraulic conductivity micro m/sec**	**Soil Reaction (pH)**
2	11 inches	20 inches	loam	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:
3	20 inches	31 inches	unweathered bedrock	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	Not reported	Max: Min:	Max: Min:

LOCAL / REGIONAL WATER AGENCY RECORDS

EDR Local/Regional Water Agency records provide water well information to assist the environmental professional in assessing sources that may impact ground water flow direction, and in forming an opinion about the impact of contaminant migration on nearby drinking water wells.

WELL SEARCH DISTANCE INFORMATION

DATABASE	SEARCH DISTANCE (miles)
Federal USGS	1.000
Federal FRDS PWS	Nearest PWS within 1 mile
State Database	1.000

FEDERAL USGS WELL INFORMATION

MAP ID	WELL ID	LOCATION FROM TP
A1	USGS40000989545	0 - 1/8 Mile WSW
B4	USGS40000989581	1/2 - 1 Mile NNW

FEDERAL FRDS PUBLIC WATER SUPPLY SYSTEM INFORMATION

MAP ID	WELL ID	LOCATION FROM TP

No PWS System Found

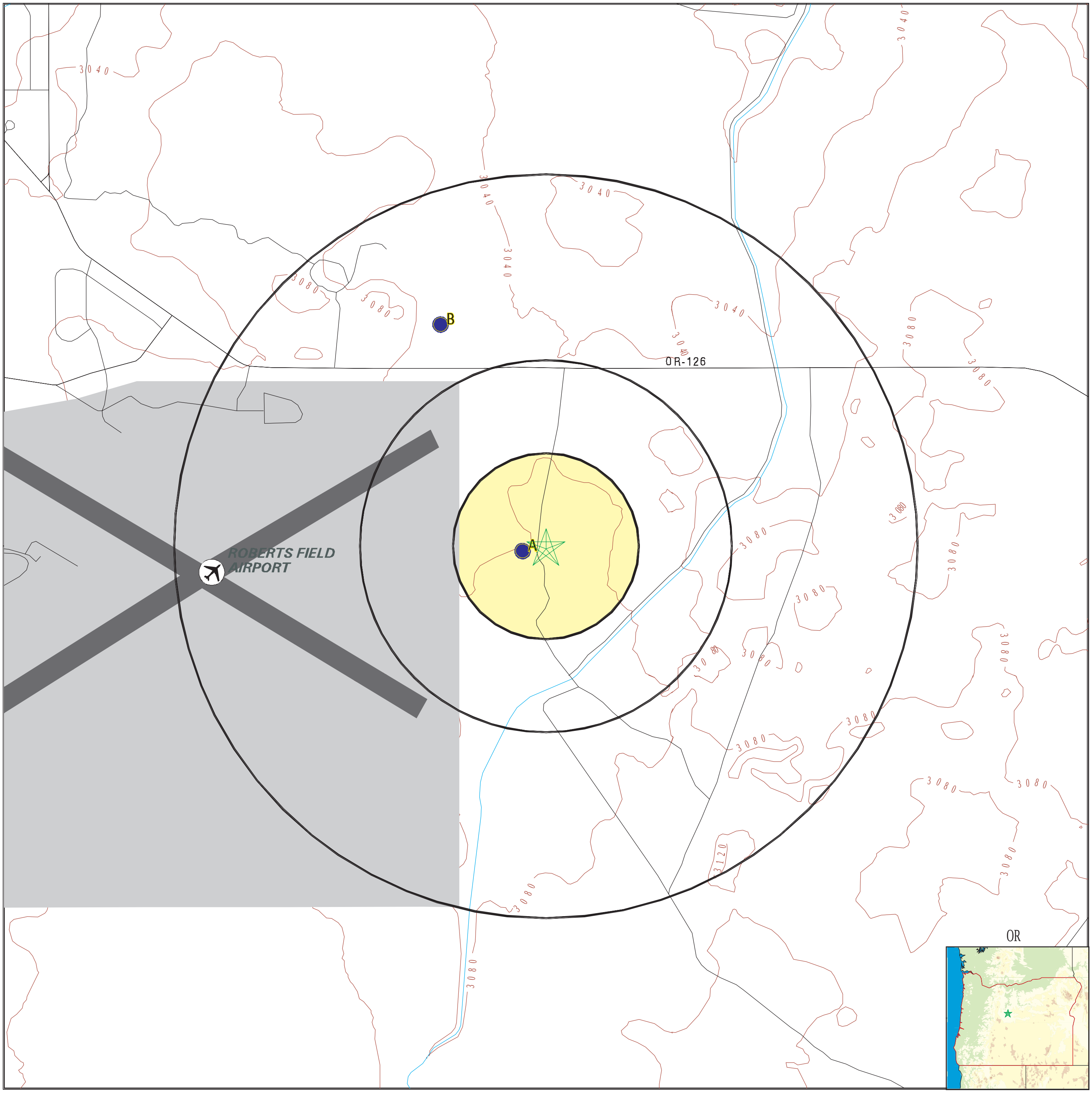
Note: PWS System location is not always the same as well location.

GEOCHECK® - PHYSICAL SETTING SOURCE SUMMARY

STATE DATABASE WELL INFORMATION

MAP ID	WELL ID	LOCATION FROM TP
A2	ORW600000010032	0 - 1/8 Mile West
B3	ORW600000009131	1/2 - 1 Mile NNW

PHYSICAL SETTING SOURCE MAP - 5464928.2s



- County Boundary
- Major Roads
- Contour Lines
- Airports
- ◎ Earthquake epicenter, Richter 5 or greater
- Ⓦ Water Wells
- Ⓟ Public Water Supply Wells
- ● Cluster of Multiple Icons

- ↑ Groundwater Flow Direction
- (GI) Indeterminate Groundwater Flow at Location
- (GV) Groundwater Flow Varies at Location
- ● Oil, gas or related wells

SITE NAME: Redmond BIAK COUTES
ADDRESS: 2522 SE Jesse Butler Cir
Redmond OR 97756
LAT/LONG: 44.255065 / 121.131854

CLIENT: AECOM
CONTACT: Brittany Kirchmann
INQUIRY #: 5464928.2s
DATE: October 25, 2018 11:42 am

GEOCHECK® - PHYSICAL SETTING SOURCE MAP FINDINGS

Map ID Direction Distance Elevation		Database	EDR ID Number
A1 **WSW** **0 - 1/8 Mile** **Lower**	Click here for full text details	**FED USGS**	**USGS40000989545**
A2 **West** **0 - 1/8 Mile** **Lower**	Click here for full text details	**OR WELLS**	**ORW600000010032**
B3 **NNW** **1/2 - 1 Mile** **Lower**	Click here for full text details	**OR WELLS**	**ORW600000009131**
B4 **NNW** **1/2 - 1 Mile** **Lower**	Click here for full text details	**FED USGS**	**USGS40000989581**

GEOCHECK® - PHYSICAL SETTING SOURCE MAP FINDINGS
RADON

AREA RADON INFORMATION

State Database: OR Radon

Radon Test Results

Zipcode	Num Tests	Maximum	Minimum	Average	# > 4 pCi/L
97756	10	1.3	0.2	0.4	0

Federal EPA Radon Zone for DESCHUTES County: 3

Note: Zone 1 indoor average level > 4 pCi/L.
: Zone 2 indoor average level >= 2 pCi/L and <= 4 pCi/L.
: Zone 3 indoor average level < 2 pCi/L.

Federal Area Radon Information for DESCHUTES COUNTY, OR

Number of sites tested: 11

Area	Average Activity	% <4 pCi/L	% 4-20 pCi/L	% >20 pCi/L
Living Area	0.820 pCi/L	100%	0%	0%
Basement	Not Reported	Not Reported	Not Reported	Not Reported

PHYSICAL SETTING SOURCE RECORDS SEARCHED

TOPOGRAPHIC INFORMATION

USGS 7.5’ Digital Elevation Model (DEM)
Source: United States Geologic Survey
EDR acquired the USGS 7.5’ Digital Elevation Model in 2002 and updated it in 2006. The 7.5 minute DEM corresponds to the USGS 1:24,000- and 1:25,000-scale topographic quadrangle maps. The DEM provides elevation data with consistent elevation units and projection.

Source: U.S. Geological Survey

HYDROLOGIC INFORMATION

Flood Zone Data: This data was obtained from the Federal Emergency Management Agency (FEMA). It depicts 100-year and 500-year flood zones as defined by FEMA. It includes the National Flood Hazard Layer (NFHL) which incorporates Flood Insurance Rate Map (FIRM) data and Q3 data from FEMA in areas not covered by NFHL.
Source: FEMA
Telephone: 877-336-2627
Date of Government Version: 2003, 2015

NWI: National Wetlands Inventory. This data, available in select counties across the country, was obtained by EDR in 2002, 2005 and 2010 from the U.S. Fish and Wildlife Service.

State Wetlands Data: Wetlands Inventory Data
Source: Oregon Geospatial Enterprise Office
Telephone: 503-378-2166

HYDROGEOLOGIC INFORMATION

AQUIFLOW^R Information System
Source: EDR proprietary database of groundwater flow information
EDR has developed the AQUIFLOW Information System (AIS) to provide data on the general direction of groundwater flow at specific points. EDR has reviewed reports submitted to regulatory authorities at select sites and has extracted the date of the report, hydrogeologically determined groundwater flow direction and depth to water table information.

GEOLOGIC INFORMATION

Geologic Age and Rock Stratigraphic Unit
Source: P.G. Schruben, R.E. Arndt and W.J. Bawiec, Geology of the Conterminous U.S. at 1:2,500,000 Scale - A digital representation of the 1974 P.B. King and H.M. Beikman Map, USGS Digital Data Series DDS - 11 (1994).

STATSGO: State Soil Geographic Database
Source: Department of Agriculture, Natural Resources Conservation Service (NRCS)
The U.S. Department of Agriculture’s (USDA) Natural Resources Conservation Service (NRCS) leads the national Conservation Soil Survey (NCSS) and is responsible for collecting, storing, maintaining and distributing soil survey information for privately owned lands in the United States. A soil map in a soil survey is a representation of soil patterns in a landscape. Soil maps for STATSGO are compiled by generalizing more detailed (SSURGO) soil survey maps.

SSURGO: Soil Survey Geographic Database
Source: Department of Agriculture, Natural Resources Conservation Service (NRCS)
Telephone: 800-672-5559
SSURGO is the most detailed level of mapping done by the Natural Resources Conservation Service, mapping scales generally range from 1:12,000 to 1:63,360. Field mapping methods using national standards are used to construct the soil maps in the Soil Survey Geographic (SSURGO) database. SSURGO digitizing duplicates the original soil survey maps. This level of mapping is designed for use by landowners, townships and county natural resource planning and management.

PHYSICAL SETTING SOURCE RECORDS SEARCHED

LOCAL / REGIONAL WATER AGENCY RECORDS

FEDERAL WATER WELLS

PWS: Public Water Systems
Source: EPA/Office of Drinking Water
Telephone: 202-564-3750
Public Water System data from the Federal Reporting Data System. A PWS is any water system which provides water to at least 25 people for at least 60 days annually. PWSs provide water from wells, rivers and other sources.

PWS ENF: Public Water Systems Violation and Enforcement Data
Source: EPA/Office of Drinking Water
Telephone: 202-564-3750
Violation and Enforcement data for Public Water Systems from the Safe Drinking Water Information System (SDWIS) after August 1995. Prior to August 1995, the data came from the Federal Reporting Data System (FRDS).

USGS Water Wells: USGS National Water Inventory System (NWIS)
This database contains descriptive information on sites where the USGS collects or has collected data on surface water and/or groundwater. The groundwater data includes information on wells, springs, and other sources of groundwater.

STATE RECORDS

Water Well Data
Source: Department of Water Resources
Telephone: 503-986-0843

OTHER STATE DATABASE INFORMATION

Oil and Gas Well Locations
Source: Department of Geology and Mineral Industries
Telephone: 971-673-1540
A listing of oil and gas well locations in the state.

RADON

State Database: OR Radon
Source: Oregon Health Services
Telephone: 503-731-4272
Radon Levels in Orgeon

Area Radon Information
Source: USGS
Telephone: 703-356-4020
The National Radon Database has been developed by the U.S. Environmental Protection Agency (USEPA) and is a compilation of the EPA/State Residential Radon Survey and the National Residential Radon Survey. The study covers the years 1986 - 1992. Where necessary data has been supplemented by information collected at private sources such as universities and research institutions.

EPA Radon Zones
Source: EPA
Telephone: 703-356-4020
Sections 307 & 309 of IRAA directed EPA to list and identify areas of U.S. with the potential for elevated indoor radon levels.

OTHER

Airport Landing Facilities: Private and public use landing facilities
Source: Federal Aviation Administration, 800-457-6656

Epicenters: World earthquake epicenters, Richter 5 or greater
Source: Department of Commerce, National Oceanic and Atmospheric Administration

Earthquake Fault Lines: The fault lines displayed on EDR’s Topographic map are digitized quaternary faultlines, prepared in 1975 by the United State Geological Survey

PHYSICAL SETTING SOURCE RECORDS SEARCHED

STREET AND ADDRESS INFORMATION

DEQ LABORATORY AND WATER QUALITY DIVISIONS

State of Oregon
Department of
Environmental
Quality

GROUNDWATER QUALITY REPORT FOR THE DESCHUTES BASIN, OREGON

March 2006

Prepared By:

David L. Cole, R.G.
Oregon Department of Environmental Quality
Laboratory Division
1712 SW 11th Avenue
Portland, Oregon 97201

Acknowledgements:

I wish to acknowledge the efforts of many people, without whose help this report would not have become a reality. First is my manager, Greg Pettit, whose technical expertise and vision figured prominently in the report's focus on DEQ data. Next are the DEQ Laboratory's Water Quality Monitoring Specialists, without whose diligence in the field, the vast majority of the data presented here would never have been collected. These people, some of whom have come and gone from DEQ, include Judy Coleman, Scott Sloan, Mark Kochan, and Richard Myzak. Other DEQ staff who collected field data include Rodney Weick, Paul DeVito, Daphne Bussey, and Jerry Grondin. Interagency personnel also contributed to the field collection effort, including Dennis Nelson and J. Potts from the Department of Human Services. Much background work went into assembling sampling networks. Carolyn Peterson assisted with this effort. The Organic and Inorganic chemists at the DEQ Laboratory, and the Department of Agriculture Laboratory, played a major role in performing the analyses, on which the data in this report are based. Marv McGlothlin assisted with data management and verification. Bob McCoy, Mary Jane Gilles, and Sigrid Schwind, of the DEQ Lab's Technical Services Section, accomplished sample tracking and data entry. Transforming the report into a web-accessible document occurred with the help of the DEQ Laboratory's LAN Administrator Nellie Bernuy-Garcia.

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EXECUTIVE SUMMARY

Preventing groundwater contamination and conserving and restoring this resource are statewide goals in Oregon. Groundwater monitoring and assessment programs provide statewide groundwater quality information.

The Deschutes Basin is located in north-central Oregon, and encompasses all or portions of eleven counties. Major land uses in the basin include forest (65%), rangeland (25%), and agricultural-urban-industrial (10%).

The DEQ and other state and local agencies have collected data and conducted several groundwater quality studies in the Deschutes Basin. This report compiles and summarizes groundwater quality information from the following sources:

- the Oregon Department of Human Services (DHS) Domestic Well Testing for Real Estate Transactions program,
- the Oregon DHS Public Water Systems program, and
- four DEQ studies.

Over the course of these studies, the following constituents were analyzed to assess groundwater quality:

- nitrate
- bacteria
- volatile organic compounds
- physical parameters
- metals
- pesticides

The DEQ studies of private, domestic water wells in the basin show some constituents exceed federal Maximum Contaminant Levels (MCLs). These constituents include nitrate (17 wells), arsenic (3 wells), and VOCs (1 well). VOC concentrations likely reflect localized contamination, due to improper storage and handling of VOC-containing materials. As such, VOC-contaminated groundwater is not a regional, aquifer-wide problem.

The Department of Human Resources, Drinking Water Program database shows numerous constituents have exceeded MCLs in some Public Water Systems (PWS). These constituents include nitrate (10 PWS), bacteria (58 PWS), lead (4 PWS), thallium (6 PWS), arsenic (4 PWS), antimony (1 PWS), and VOCs (2 PWS).

Potential sources for Deschutes Basin groundwater nitrate contamination include high densities of on-site septic systems in areas where permeable, sandy soils overlie shallow, unconfined aquifers. Poor well construction and maintenance activities increase wells' vulnerabilities to this contamination.

Based on existing data, further investigations and monitoring are warranted in the Prineville area, where sampling should be repeated for nitrates, heavy metals, pesticides, and VOCs.

In the La Pine area, DEQ and Deschutes County should consider steps to better protect the shallow drinking water aquifer from nitrate contamination, due to septic systems. The county and/or state should establish a program to measure nitrate groundwater trends over time.

The DEQ should also conduct an initial ambient groundwater sampling event in the Redmond area.

INTRODUCTION

In 1989, the Oregon Legislative Assembly passed a comprehensive set of laws known as the Groundwater Protection Act. These laws established the state goal to prevent groundwater contamination:

> "... it is the goal of the people of the State of Oregon to prevent contamination of Oregon's groundwater resource while striving to conserve and restore this resource and to maintain the high quality of Oregon's groundwater resource for present and future uses." (Oregon Revised Statutes 468B.155)

As part of the Act, the Department of Environmental Quality (DEQ), the Water Resources Department, and Oregon State University are directed to:

> "… conduct an ongoing statewide monitoring and assessment program of the quality of the groundwater resource of this state." (Oregon Revised Statutes 468B.190)

Other state agencies, including the Department of Human Services and local agencies, also conduct groundwater monitoring and assessment programs.

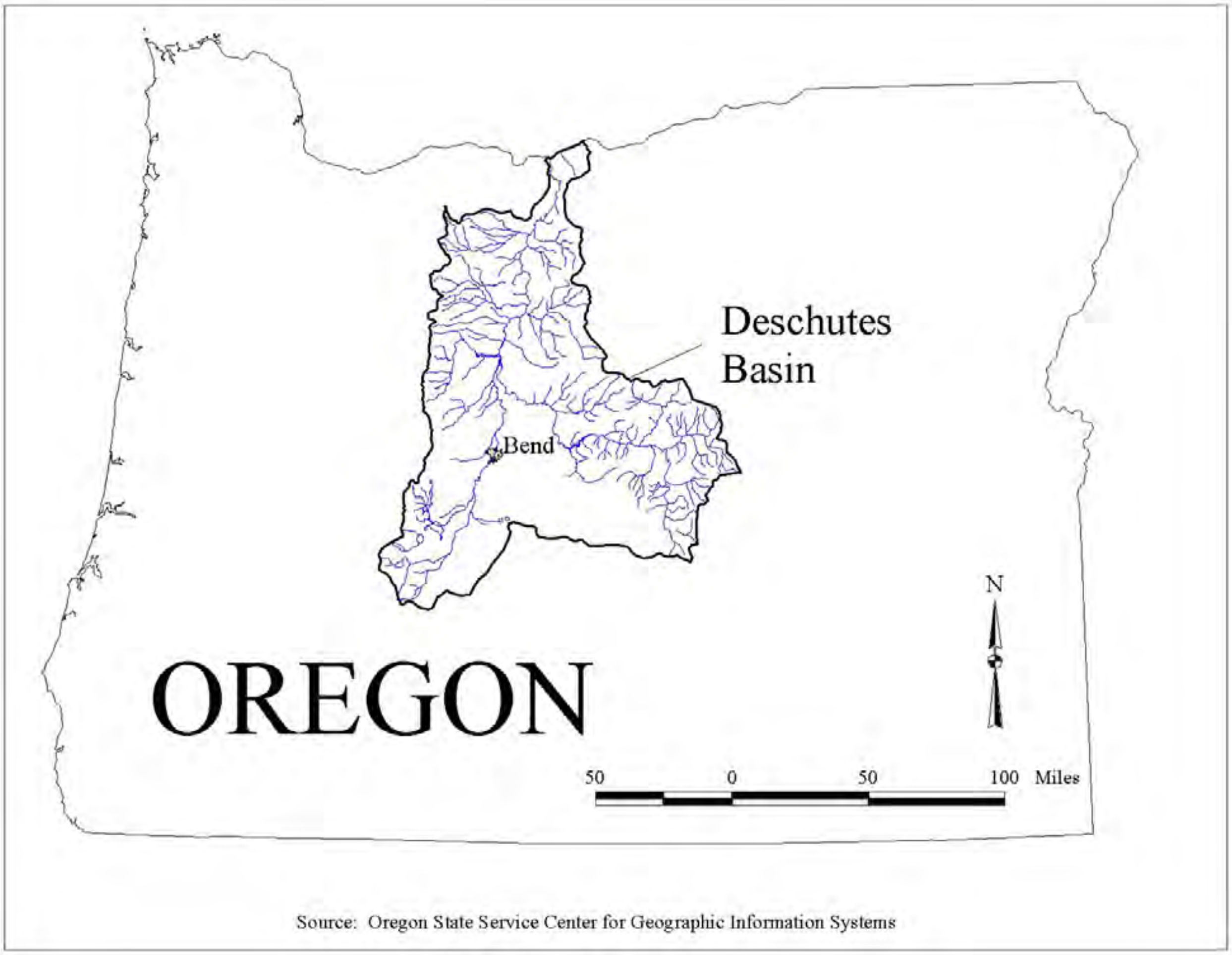
This report presents the following for the Deschutes Basin:

- background information on the Deschutes' environmental setting,
- general information about basin geology and hydrogeology,
- groundwater use information,
- a compilation of groundwater quality data from the DEQ, and other state and local agency studies,
- summary information with references to other reports when available,
- links to data repositories or on-line information and data sources,
- status updates for local studies in the Deschutes Basin,
- a discussion of potential pollutant sources in the basin,
- an evaluation of the Deschutes' overall groundwater quality status, and
- recommendations for potential actions that could be taken.

ENVIRONMENTAL SETTING

Geography

The Deschutes Basin is one of the state's 18 major river drainage basins. The basin occupies about 10,850 square miles in north-central Oregon (Figure 1). The Oregon Water Resources Department (OWRD) defines the Deschutes Basin for water management purposes OAR 690-505.

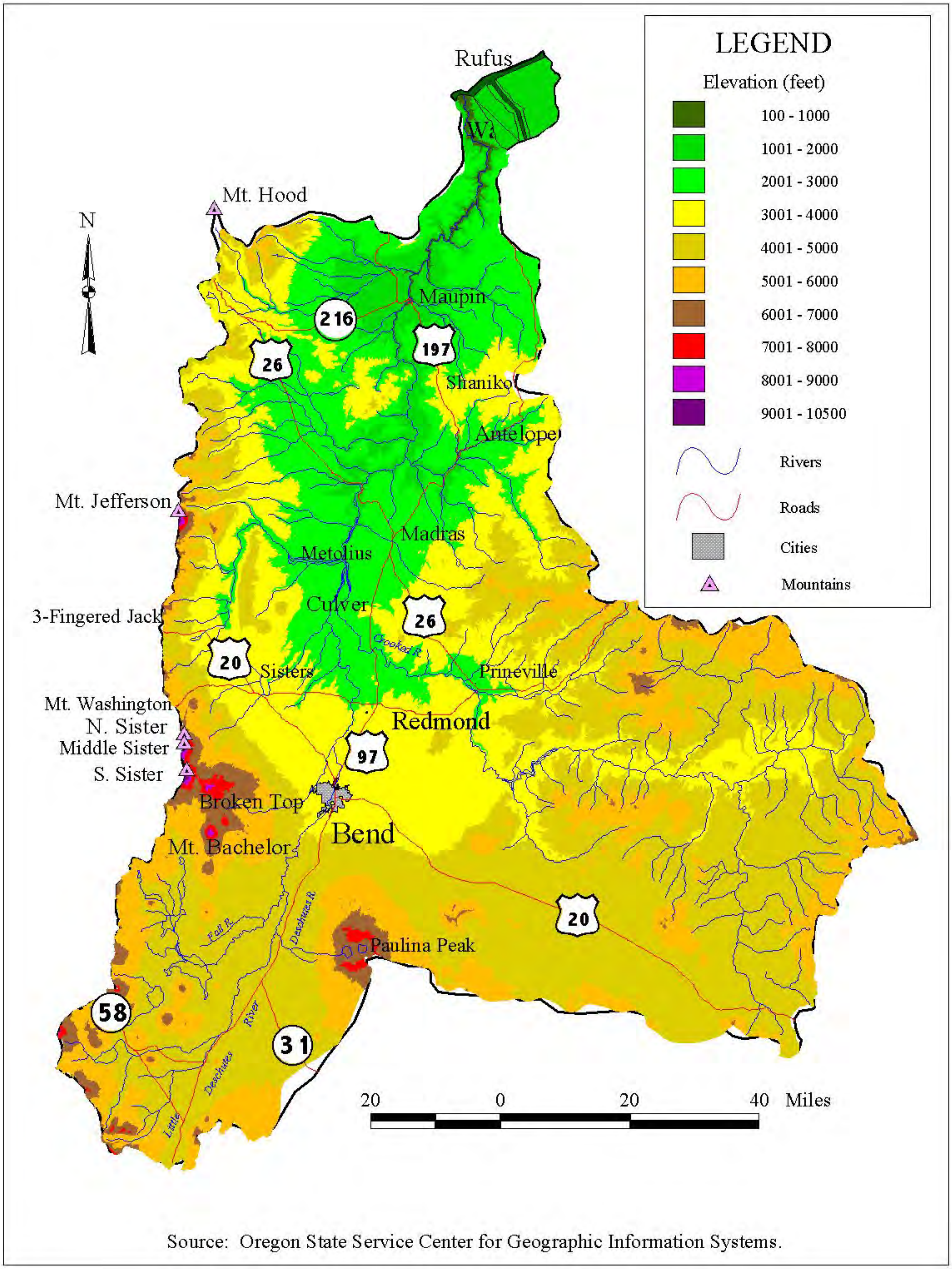


Source: Oregon State Service Center for Geographic Information Systems

Figure 1. Location of Deschutes Basin in Oregon.

The Deschutes Basin encompasses all or portions of the following eleven counties: Crook, Deschutes, Grant, Harney, Hood River, Jefferson, Klamath, Lake, Sherman, Wasco, and Wheeler.

Figure 2 shows the Deschutes Basin's major geographic features.



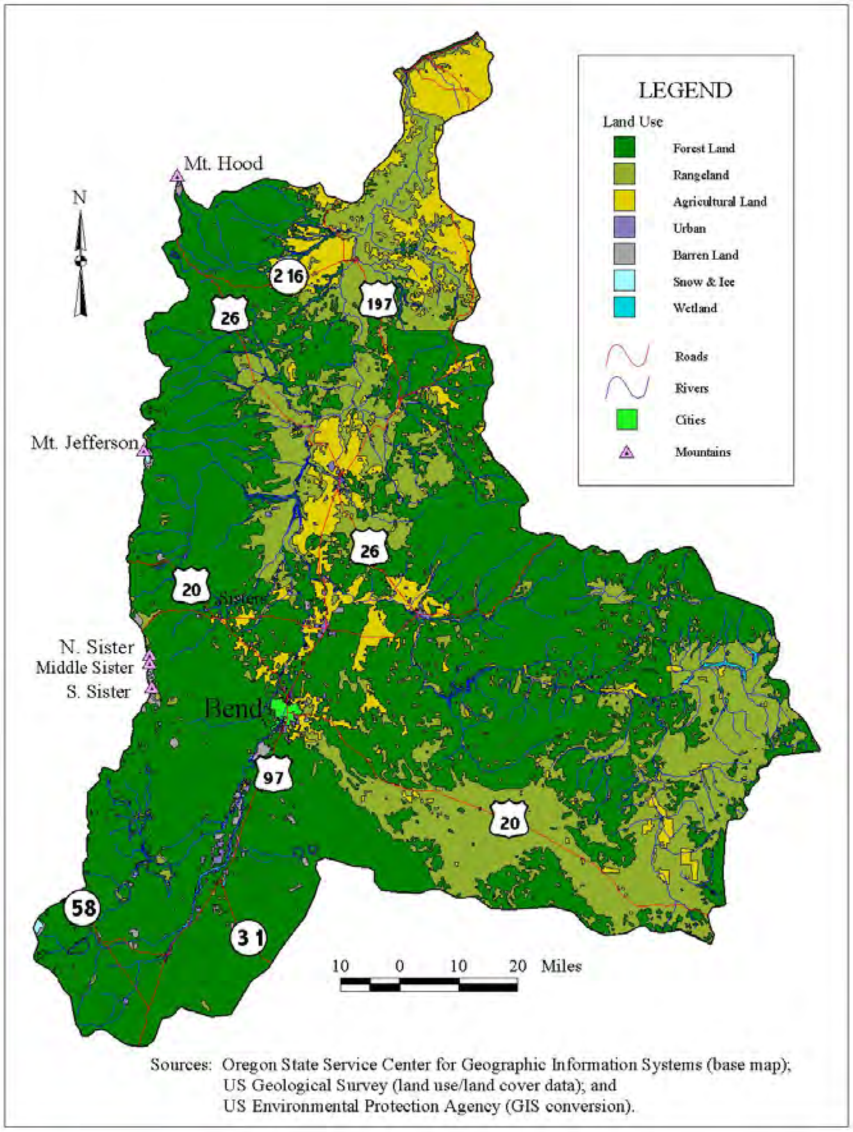
Source: Oregon State Service Center for Geographic Information Systems.

Figure 2. Map of Deschutes Basin, showing major geographic features.

Land Use and Population

Land use in the Deschutes Basin consists primarily of forest land (65%), rangeland (25%), and agricultural and urban (10%), with minor amounts in barren land, wetland, and snow and ice (Figure 3).

The resident population within the Deschutes Basin is about 90,000 (U.S. Census Bureau, 2003). Central Oregon, which includes the Deschutes Basin, is well known for its recreational activities. As a result, the Deschutes Basin has many tourist attractions. The Oregon Travel Commission statistics for 1997 indicated over 3.5 million pleasure day trips occurred in Central Oregon (http://otc.traveloregon.com).



Sources: Oregon State Service Center for Geographic Information Systems (base map); US Geological Survey (land use/land cover data); and US Environmental Protection Agency (GIS conversion).

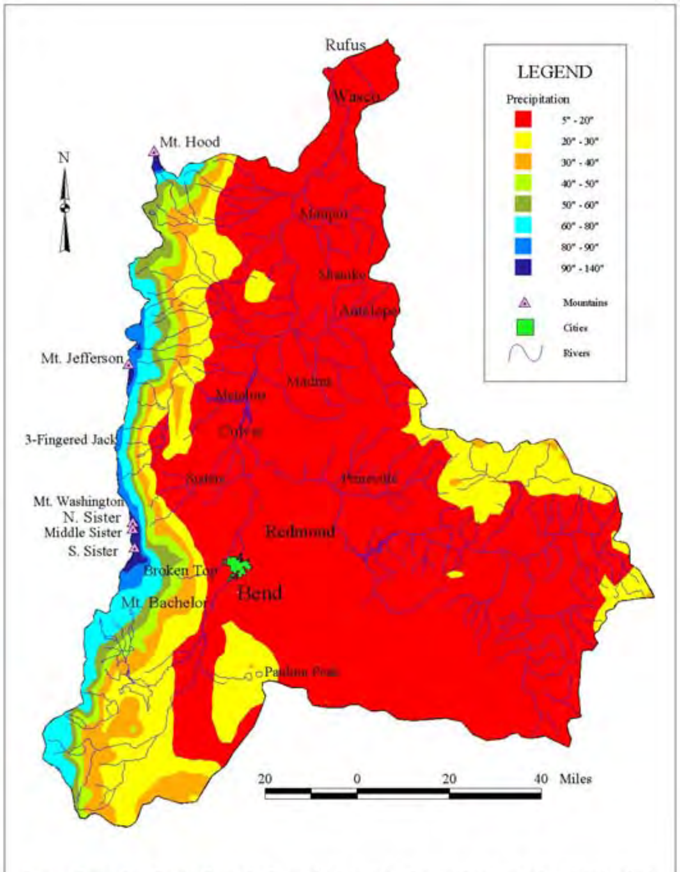
Figure 3. Land Use and Land Cover, Deschutes Basin, Oregon.

Climate and Precipitation

The climate in the Deschutes Basin ranges from cold, alpine conditions along the basin's high western border, to dry, desert-like conditions in the basin's lower, central areas. In the high mountain passes, along the basin's western border, temperatures range from an average wintertime low of about 20°F, to an average summertime high of about 72°F. Over the period of record (1971 – 2000), this area has seen an extreme low temperature of -16°F, and an extreme high temperature of 89°F. In this part of the basin the average annual precipitation is about 84-inches, and an average annual snowfall of about 420-inches (http://www.ocs.orst.edu/).

In the drier, lower part of the basin, near Prineville, the average wintertime low is about 21°F, and the average summertime high is about 86°F. Over the same period of record, the extreme low and high temperatures were -34°F, and 107°F, respectively. This part of the basin receives an annual precipitation of about 10.5-inches, with about 9-inches of average annual snowfall.

Figure 4 shows the average annual precipitation distribution in the Deschutes Basin.



Source: Oregon State Service Center for Geographic Information Systems (base map and precipitation data).

Figure 4. Annual precipitation distribution in the Deschutes Basin.

Geology

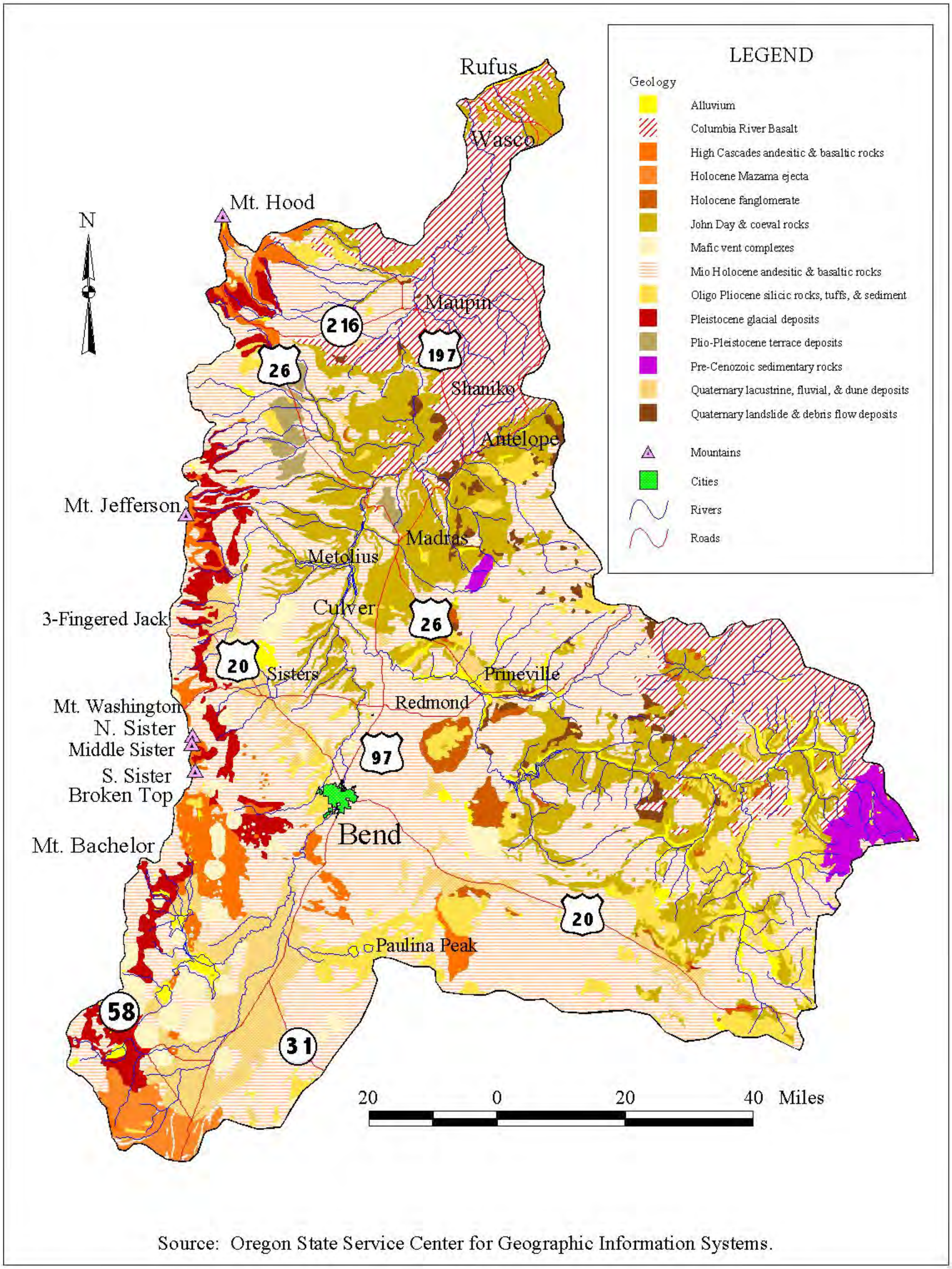
The Deschutes Basin geology is composed predominantly of volcanic rocks (Figure 5). However, at the basin's southeast corner, in the headwaters of the Crooked River, Cretaceous age (65 – 70 million years ago) marine sedimentary rocks occur. As the region underwent tectonic uplift, the seas retreated westward, and a period of erosion took place. Before the Columbia River Basalts began to erupt in Miocene time, volcanoes of the Clarno and John Day periods covered the area with widespread, thick deposits of lava and ash. Fossil bearing deposits in the Clarno and John Day Formations testify to the tropical climatic conditions prevalent during those ancient times. A wide range of fossil fauna and flora have been found in these deposits, including specimens of avocado, cinnamon, palm, and fig plants, as well as tapirs, rhinoceros, titanothere, and oreodons.

Near the basin's southern border is Newberry Caldera. This eruptive center lies near the convergence of three fault zones. These fault zones are known as the Brothers, Green Ridge and Sisters, and Walker Rim fault zones. At this fault zone convergence, rocks at the Newberry volcano formed younger than and separate from, the High Cascade vents along the basin's western border. Due to its wide variety of striking volcanic features, this area was dedicated in 1991 as Newberry Volcanoes National Monument.

Many of the basin's volcanic rocks are mineralogically bi-modal. That is, the rocks have strikingly different compositions, ranging from dark-colored basalt, to light-colored rhyolite. Other volcanic rocks in the basin are the result of ash fall accumulations. Magnificent examples of the latter, known as tuff, are displayed in the towering cliffs of Smith Rock State Park, seven miles northeast of Redmond.

Along the Deschutes river, some 6 miles west of Terrebonne, diatomite, or diatomaceous earth, is exposed. This material is composed of microscopic, single-celled glassy aquatic plants. These organisms inhabited a late Miocene to early Pliocene age lake. This material can absorb up to 300 percent of its own weight in water. It is also fireproof, resists chemicals, and is mined for use as cat box litter, drinking water filters, and in chemical laboratories.

South of Bend, just east of U.S. Highway 97, is Lava River Cave. This is one of Oregon's longest, uncollapsed lava tubes (5,040 feet long). The formation is the result of a lava flow where the central part of the flow remained molten, while the sides and roof cooled and hardened. When the eruption stopped it left numerous interesting features. These features include flow lines, benches, vertically stacked lava tubes, keyhole-shaped tunnel sides, and sand castles. The latter is the result of surface water percolating through the tube ceiling, carving out tunnel floor sands into miniature badlands formations.



Source: Oregon State Service Center for Geographic Information Systems.

Figure 5. Generalized geologic map of the Deschutes Basin.

Hydrogeology

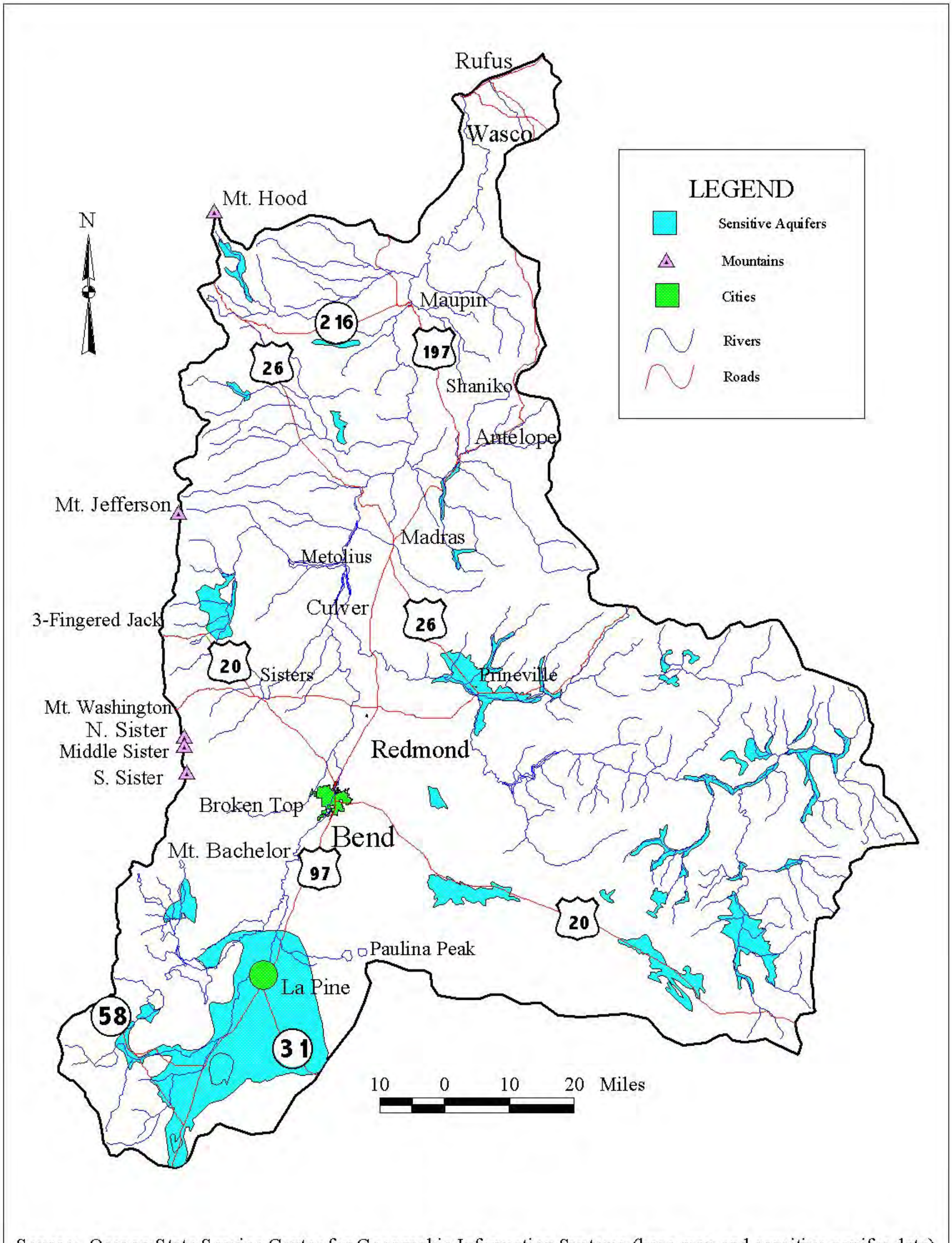
Groundwater use in the Deschutes Basin taps both shallow and deep aquifers. The host materials for these aquifers include both volcanic rock and unconsolidated sediments. Information on some of these aquifers' hydrogeological characteristics comes from various investigations, summarized below.

In June 1991 David S. Morgan, Dwight Q. Tanner, and Milo D. Crumrine of the U.S. Geological Survey (USGS), began a hydrological and water quality investigation in the vicinity of Newberry Caldera (USGS WRIR 97-4088). Cooperating with the USGS in this investigation were the Bonneville Power Administration, U.S. Forest Service (USFS), and Bureau of Land Management. The purpose of the investigation was to characterize hydrologic and water-quality conditions at the volcano, principally within the volcanic center's caldera, prior to developing potential geothermal resources.

Beginning in 1999, the USGS, in cooperation with the DEQ, and Deschutes County Community Development Department, began a nitrate study in the La Pine area (USGS OR 186). Much of the area surrounding La Pine has been subdivided into lots as small as ½ acre in size. Virtually all of the lots developed to date use groundwater from shallow, unconfined aquifers. Most of the wells on these lots are less than 50 feet deep. These lots also use on-site septic systems to dispose of waste water. The high density of the on-site septic systems has led to elevated nitrate levels in the shallow aquifers. One of the project's objectives has been to develop a groundwater model, capable of predicting groundwater nitrate levels, under various water use and septic system scenarios.

The Oregon Water Resources Department (OWRD), in cooperation with the USGS, is currently conducting research on the Deschutes Basin's groundwater resources. The basin's surface water resources have been fully appropriated for many years, and stream flows are locally below legally set minimums at certain times of the year. Because surface water rights are no longer available, virtually all new development relies on groundwater. Groundwater is abundant in parts of the basin, and with the high level of development in the area, concerns exist about causing seasonal and long-term aquifer water level declines. This could cause further stream flow depletion. A secondary issue is the potential effect of lining irrigation canals. Hundreds of miles of leaking irrigation canals traverse the basin. Lining these canals to prevent leakage is being considered to conserve water. Leakage from these canals may be providing significant recharge to the groundwater system, so the overall effects of eliminating this recharge are unknown. This study has produced four reports to date. More information on this project is available at the following OWRD web site: OWRD OR161.

Sweet and others (1980) produced a statewide map of aquifers sensitive to contamination. Figure 6 shows the sensitive aquifers identified in the Deschutes Basin.



Source: Oregon State Service Center for Geographic Information Systems (base map and sensitive aquifer data).

Figure 6. Sensitive aquifers in the Deschutes Basin.

GROUNDWATER USE

Overview

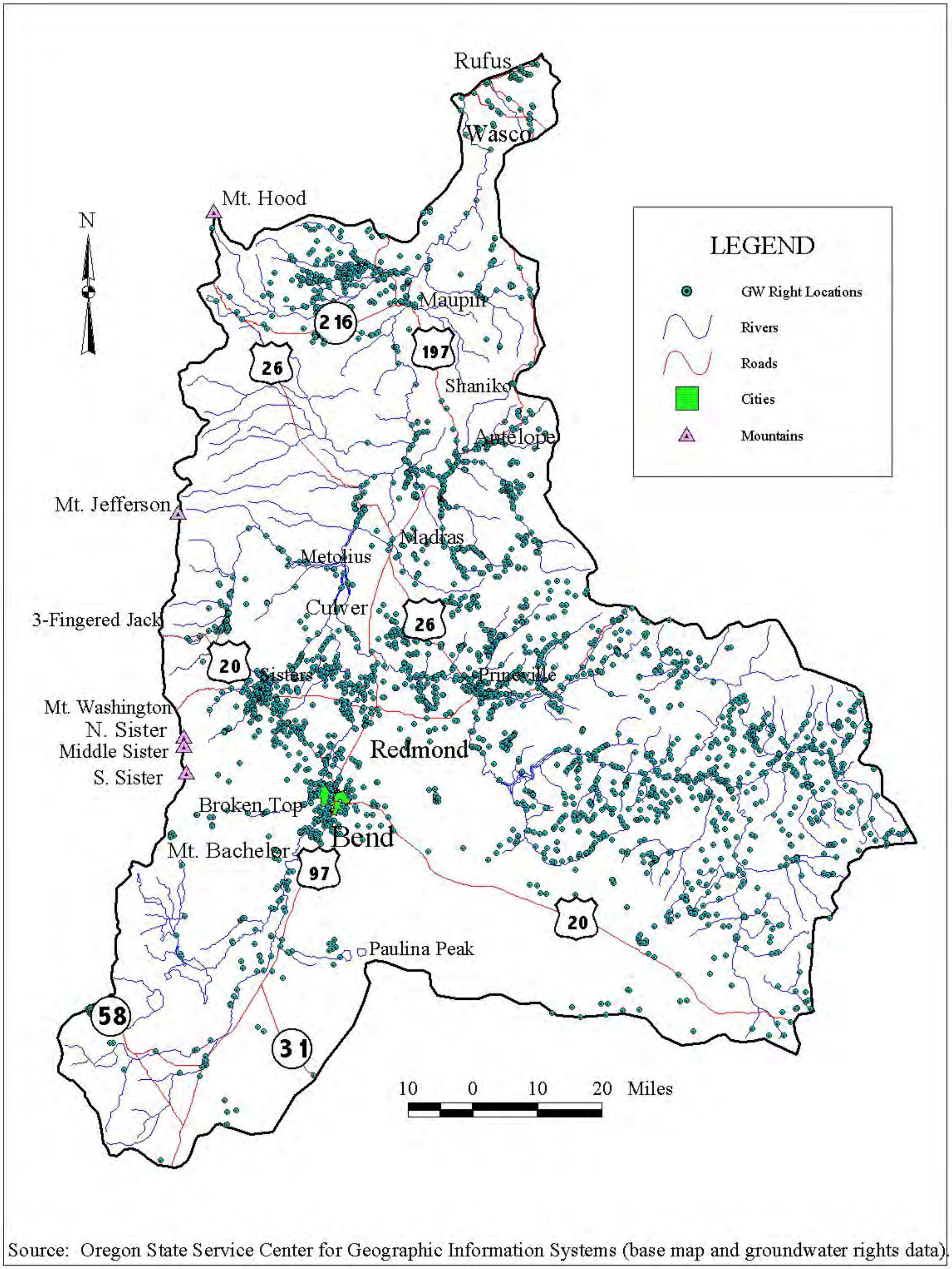
The Oregon Water Resources Department (OWRD) manages statewide groundwater use through water rights applications, permits, certificates, transfers, and leases. Groundwater in the Deschutes Basin is available for the following beneficial uses: domestic water use, livestock, municipal water use, irrigation, power development, industrial uses, mining, recreation, wildlife, and fish (OAR 690-410). Exempt uses do not require a permit. Exempt uses (ORS 537.545) include the following:

- domestic use under 15,000 gallons a day,
- stock watering,
- small lawn or garden watering,
- school grounds watering,
- down-hole heat exchange,
- industrial or commercial operations using less than 5,000 gallons a day, and
- land application associated with permitted uses.

Deschutes Basin groundwater use is discussed in the next three sections on Groundwater Rights, Domestic and Other Exempt Uses, and Public Water Systems. Specific water right information can be accessed through the OWRD website at: OWRD Water Rights.

Groundwater Rights

OWRD information shows a total of 9,043 water rights on record in the Deschutes Basin. Of these, 5,710 are points of diversion (POD), 1,481 of which use groundwater, or a combination of surface water and groundwater, for campground, domestic, fish, irrigation, manufacturing, municipal, stock, and wildlife (Figure 7). Of the total number of water rights, 3,333 are points of use, 786 of which use groundwater as their source. Details on water rights can be obtained through the following link to the OWRD web site: OWRD Water Rights.



Source: Oregon State Service Center for Geographic Information Systems (base map and groundwater rights data).

Figure 7. Locations of groundwater rights points of diversion in the Deschutes Basin.

Domestic and Other Exempt Uses

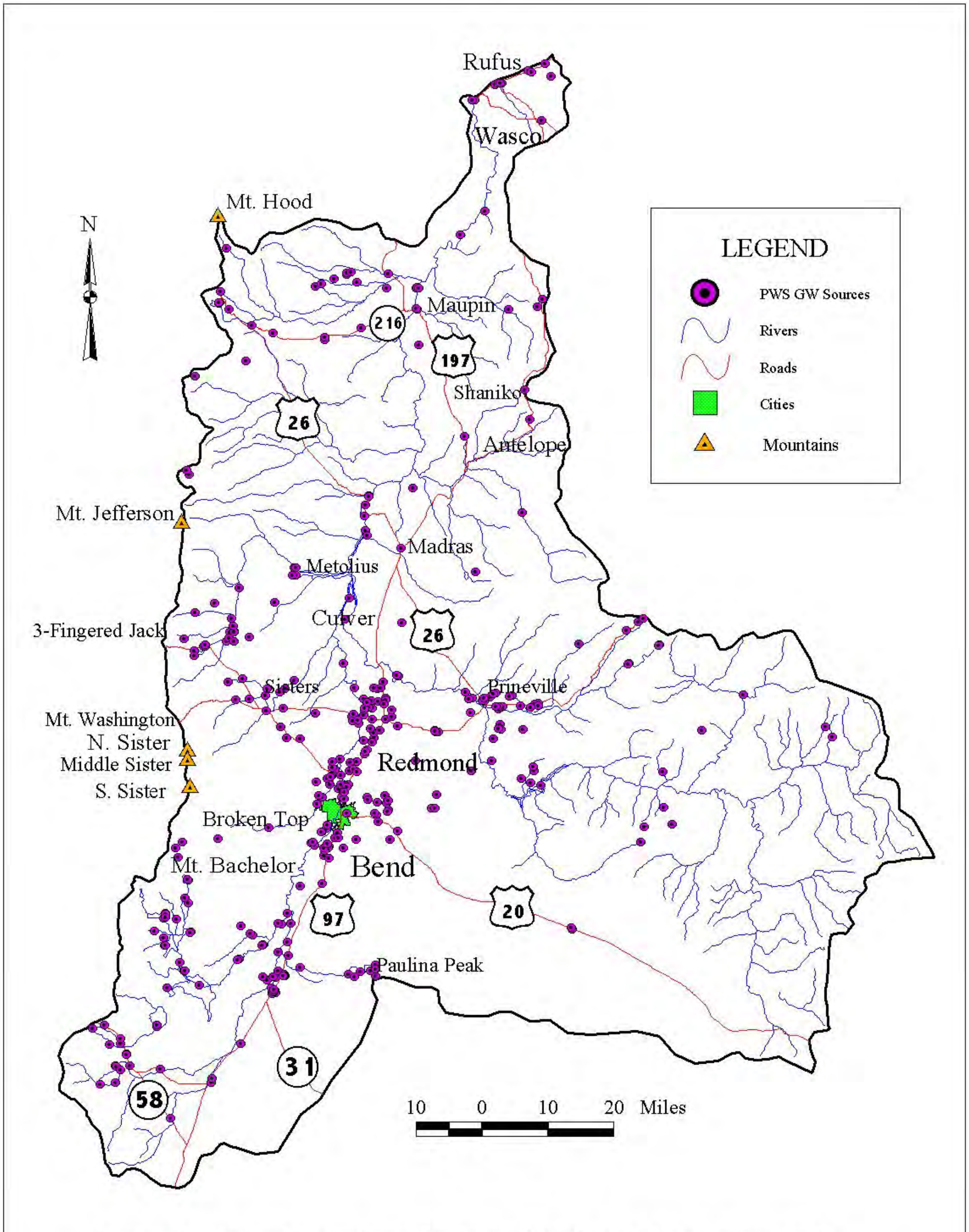
No permit is required to use groundwater for domestic purposes. This means there are no records on the amount of groundwater used to provide drinking water to Deschutes Basin households. Current statutes (ORS 537.765) and administrative rules (OAR 690-205-0210) require well logs to be filed with OWRD upon well completion. The number of private, domestic water wells constructed and reported to OWRD estimates the potential domestic water users.

The OWRD database (OWRD Groundwater) contains 17,504 domestic water well logs on file for the Deschutes Basin (B. Devyldere, personal communication, 8/5/04). The number of water wells in the basin is probably higher since, prior to 1955, state law did not require water well owners to file well logs for wells drilled and completed on their property (T. Eichenlaub, OWRD, personal communication, 8/11/03).

Public Water Systems

The Deschutes Basin has 373 groundwater-based Public Water Systems (PWS) (Figure 8). These systems are designed to provide water to over 145,500 people. The PWS shown on Figure 8 use groundwater exclusively, or use a combination of groundwater and surface water, to supply various public uses, including municipal drinking water.

Water quality information for individual PWS is available through the Oregon Department of Human Services Drinking Water Program (http://www.ohd.hr.state.or.us/dwp/about.cfm), and can be accessed on-line at: http://170.104.158.16/.



Sources: Oregon State Service Center for Geographic Information Systems (base map); Department of Human Services, Drinking Water Program (Public Water Supply data).

Figure 8. Locations of groundwater-based Public Water Systems in the Deschutes Basin.

GROUNDWATER QUALITY CONCERNS AND STUDIES

Overview

The Groundwater Quality Protection Act mandates the DEQ and other state agencies to conduct on-going statewide monitoring and assessment of statewide groundwater quality (ORS 468B.190). The DEQ and other local and state agencies have collected data and conducted several groundwater quality studies in the Deschutes Basin. Statewide and regional assessments conducted in the early 1980s provided initial groundwater quality information. The DEQ and other agencies have conducted additional, local scale assessments, in response to specific local concerns.

Throughout this report, references are made to drinking water standards, maximum contaminant levels (MCLs), and action levels. According to the U.S. Environmental Protection Agency (EPA), the MCL for a given constituent is the concentration above which the EPA considers the levels to be unsafe for human consumption. The EPA requires that public water supplies use treatment techniques to control their water's corrosiveness. The action levels referred to in this report apply to copper and lead. The action levels for these constituents are 1.3 mg/L (copper), and 0.015 mg/L (lead).

Another area of concern in the Deschutes Basin is the sensitive La Pine groundwater aquifer. The DEQ performed initial sampling of domestic wells in 1978 and 1979 to determine whether there was shallow aquifer contamination. Positive test results led the DEQ to authorize Century West Engineering Corporation to conduct further studies in the area. The 1982 Century West study found nitrates as high as 41 mg/L, well above the Federal Drinking Water Standard of 10 mg/L. The results of this study formed the basis for an administrative rule requiring a community sewage collection, treatment, and disposal system for La Pine's core business area.

In 1993 the DEQ developed a Master Plan for a Statewide Ambient Groundwater Monitoring Program (Cole and Pollock, 1993). The DEQ identified the groundwater in and around Prineville as a priority area, based on data collected as part of the DEQ's ambient groundwater quality monitoring program, and conducted a groundwater quality study in late June and early July 1993.

The Plan also identified the La Pine area as needing further assessment. The DEQ conducted a groundwater quality study in the summer of 1993. In 1995 Deschutes County requested the DEQ assess the effect of residential development on groundwater quality in the La Pine area. The DEQ then performed computer modeling to evaluate groundwater flow, and nitrate fate and transport. The results of the modeling created additional interest, and in June 1999, the USGS, in cooperation with the DEQ and Deschutes County Environmental Health Division, began an on-site wastewater treatment and disposal demonstration project.

The DEQ has collected and analyzed groundwater samples at three permitted landfills in the Deschutes Basin. The landfills are Crook County near Prineville, Knott Pit in Bend, and Southwest, between Sunriver and La Pine. The Solid Waste Facilities section of this report summarizes water quality monitoring results from sampling events at these landfills. Another landfill of concern is the now closed Box Canyon landfill, near Madras. Although the DEQ has not conducted any split sampling at this landfill, the DEQ Cleanup Program and Jefferson County are conducting an investigation to evaluate the nature and extent of groundwater effects from the closed landfill. Constituents of concern include perchloroethylene, trichloroethene, and their degradation products.

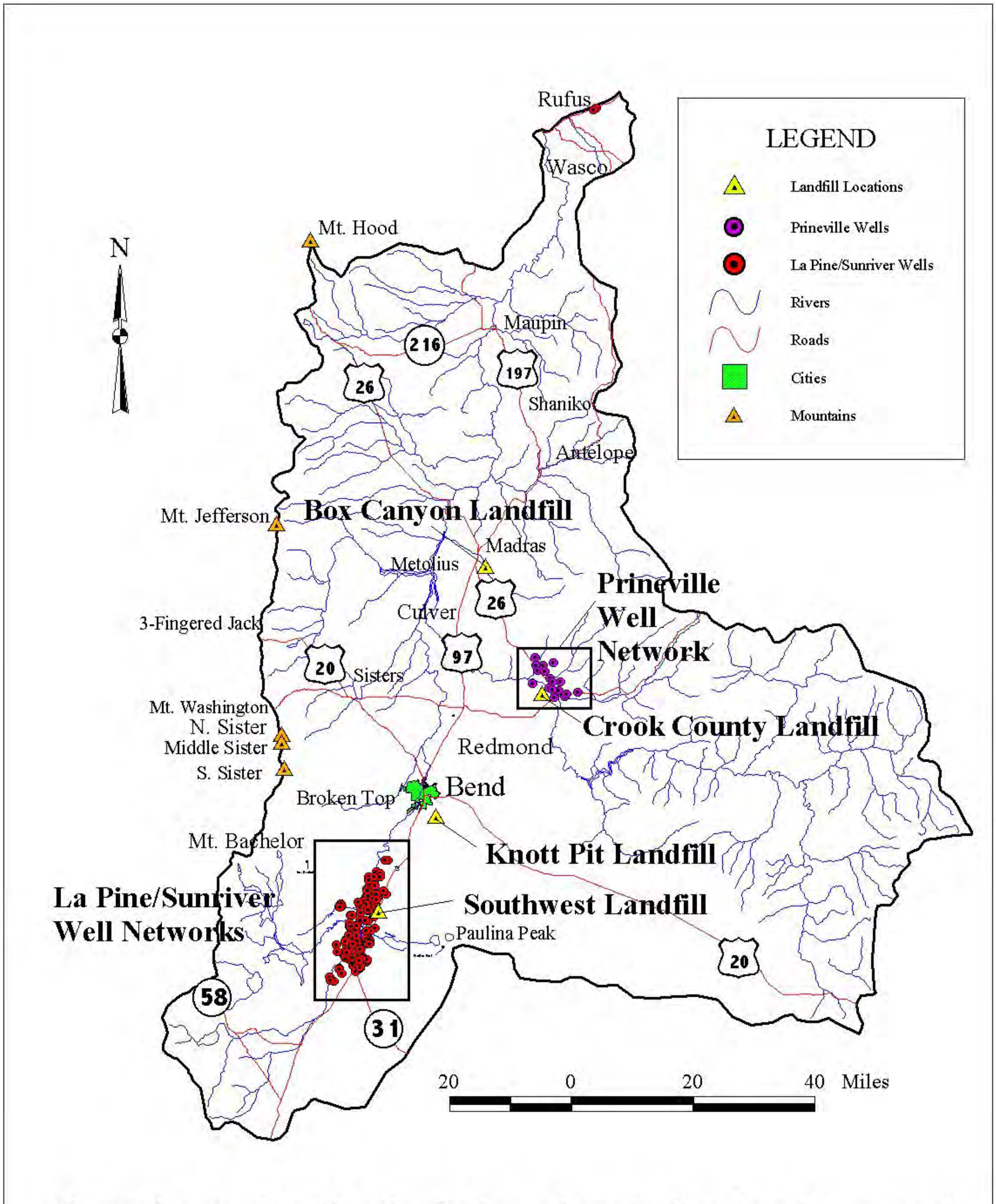
This report summarizes information of the basinwide studies, and specific area studies. Figure 9 shows the study area locations. The following section discusses the results.

Basinwide Studies

- Domestic Well Testing for Real Estate Transactions - Oregon Department of Human Services (DHS).
- Public Water Systems - DHS.

Area Studies

- La Pine Groundwater Quality Study (1978 – 1979) - Oregon Department of Environmental Quality (DEQ).
- La Pine Aquifer management Plan (1982) - Century West Engineering Corporation.
- Prineville Groundwater Quality Study (1993) - DEQ.
- La Pine Groundwater Quality Study (1993) - DEQ.
- La Pine Groundwater Quality and Computer Modeling Study (1995) - DEQ.
- La Pine National On-Site Wastewater Treatment and Disposal Demonstration Project (1999) - DEQ, in cooperation with the U.S. Geological Survey and Deschutes County Environmental Health Division.



Groundwater Quality Study Locations in the Deschutes Basin.

Sources: Oregon State Sercie Center for Geographic Information Systems (base map);
Oregon Department of Environmental Quality (well network data).

Figure 9. Groundwater Quality Studies, Deschutes Basin, Oregon

Basinwide Studies

Domestic Well Testing for Real Estate Transactions - Oregon Department of Human Services

Summary

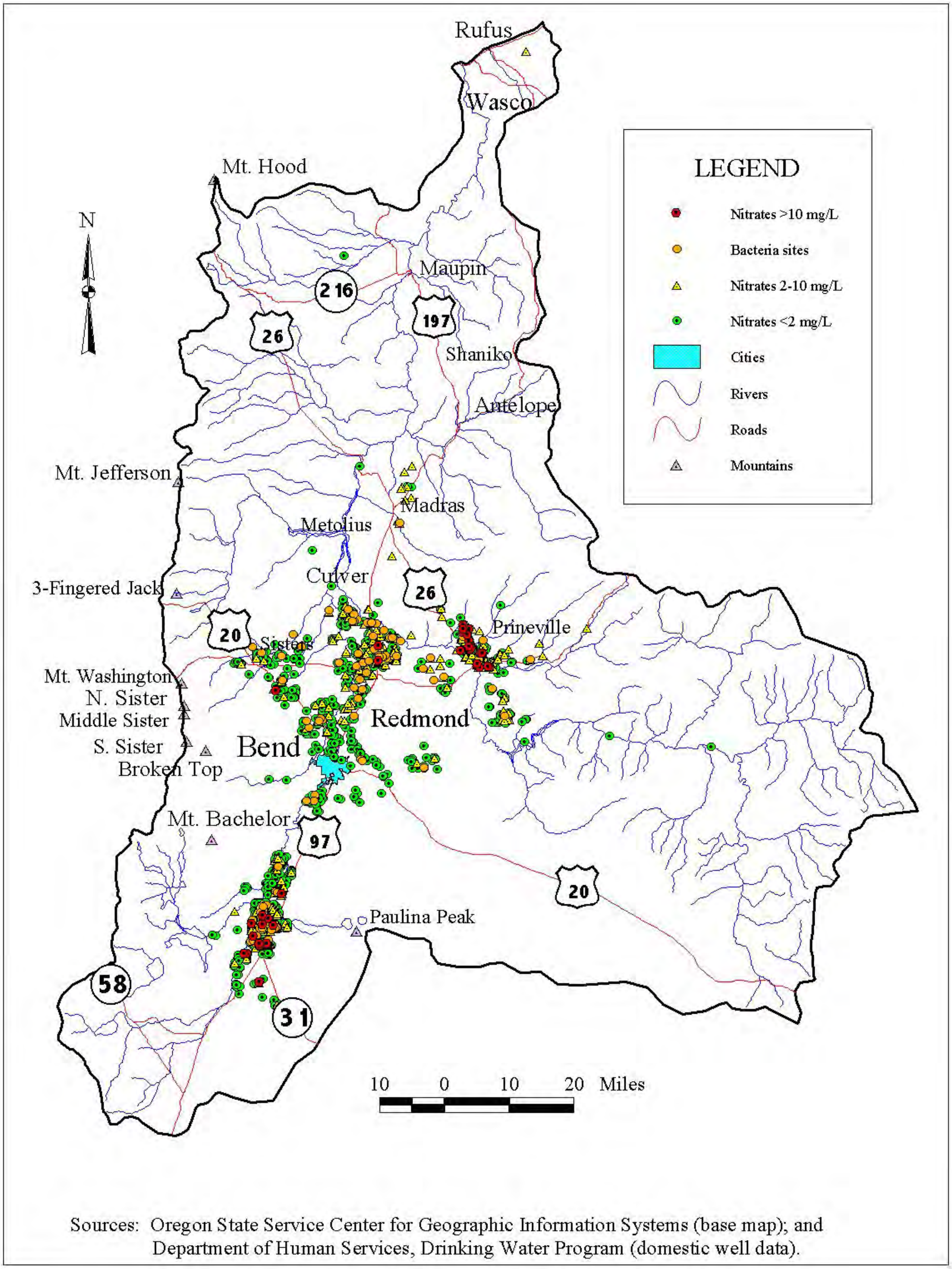
In 1989, Oregon established a program to monitor the quality of groundwater used for domestic purposes (ORS 448.271). As part of this program, for any real estate transaction involving a domestic water supply well, the seller must test the well water for nitrate and total coliform bacteria. The seller must complete and submit a Water Systems Data Sheet, including the laboratory test results, to the Oregon Department of Human Services (DHS).

Results

The DHS database shows 7,137 tests have been performed in the Deschutes Basin. The results include data compiled between 1989 and 2003 for both nitrate and bacteria. Because some wells were involved in more than one transaction, the database does not include the actual total of individual wells tested. The results include the following:

- 2,903 samples were analyzed for nitrate, of which 47 (2%) exceeded the drinking water standard of 10 mg/L.
- 655 of the nitrate tests (23%) had levels between 2 mg/L and 10 mg/L (2 mg/L is the approximate cutoff point, above which the DHS considers anthropogenic influences to be present (DHS Nitrate Facts).
- 2,203 of the nitrate tests (75%) had levels less than 2 mg/L.
- 190 of the 4,235 bacteria tests (4%) were positive.

Information about the Real Estate Transaction Domestic Well Testing Program is available on-line at http://www.dhs.state.or.us/publichealth/dwp/dwt.cfm. Data can be obtained from the DHS or the DEQ. Figure 10 shows the locations of the wells tested as part of the DHS Real Estate Transaction Program.



Sources: Oregon State Service Center for Geographic Information Systems (base map); and Department of Human Services, Drinking Water Program (domestic well data).

Figure 10. Well Locations for Department of Human Services, Drinking Water Program, Real Estate Transaction Program Testing for Nitrates and Bacteria.

Public Water Systems - Oregon Department of Human Services

Summary

The Oregon Department of Human Services Drinking Water Program (DHSDWP) database shows 373 groundwater-based public water systems (PWS) provide drinking water to Deschutes Basin residents. The DHSDWP Program maintains water quality information on these systems. Water quality information for individual systems is available through the DHSDWP (http://www.ohd.hr.state.or.us/dwp/about.cfm), and can be accessed on-line at: (http://170.104.158.16/).

Results

Table 1 summarizes testing results for groundwater-based PWS. Not all PWS have the same period of record for testing results, nor did they all test for the same constituents during their period of record. The results include the following:

- Nitrate was detected in 360 PWS, and exceeded the 10 mg/L federal drinking water Maximum Contaminant Level (MCL) in 10 systems. Two-hundred thirty-two PWS had nitrate levels equal to or greater than 2 mg/L, indicative of anthropogenic influences.
- Bacteria were detected in 58 PWS.
- Lead was detected in 4 wells, and exceeded the federal EPA Action Level of 0.015 mg/L in all four wells.
- Thallium was detected in 7wells, and exceeded the MCL (0.002 mg/L) in 6 wells.
- Arsenic was detected in 4 wells, and exceeded the MCL (0.01 mg/L) in all wells.
- Tetrachloroethylene was detected, and exceeded the MCL (0.005 mg/L), in one well.
- Dichloromethane was detected, and exceeded the MCLs (0.005 mg/L), in one well.
- Toluene was detected in three wells, but did not exceed the MCL (1 mg/L).
- Eighteen other PWS reported detections of VOCs, but the records did not specify the compounds or their concentrations.
- One PWS reported a pesticide detection, but did not specify the compound or its concentration.
- Antimony was detected in two wells, and exceeded the MCL (0.006 mg/L) in one of the wells.
- Cadmium and chromium were each detected in one well, but did not exceed the MCLs (0.005 mg/L and 0.1 mg/L respectively).
- Mercury was detected in 4 wells, but did not exceed the MCL (0.002 mg/L).

Table 1. Deschutes Basin Public Water Systems

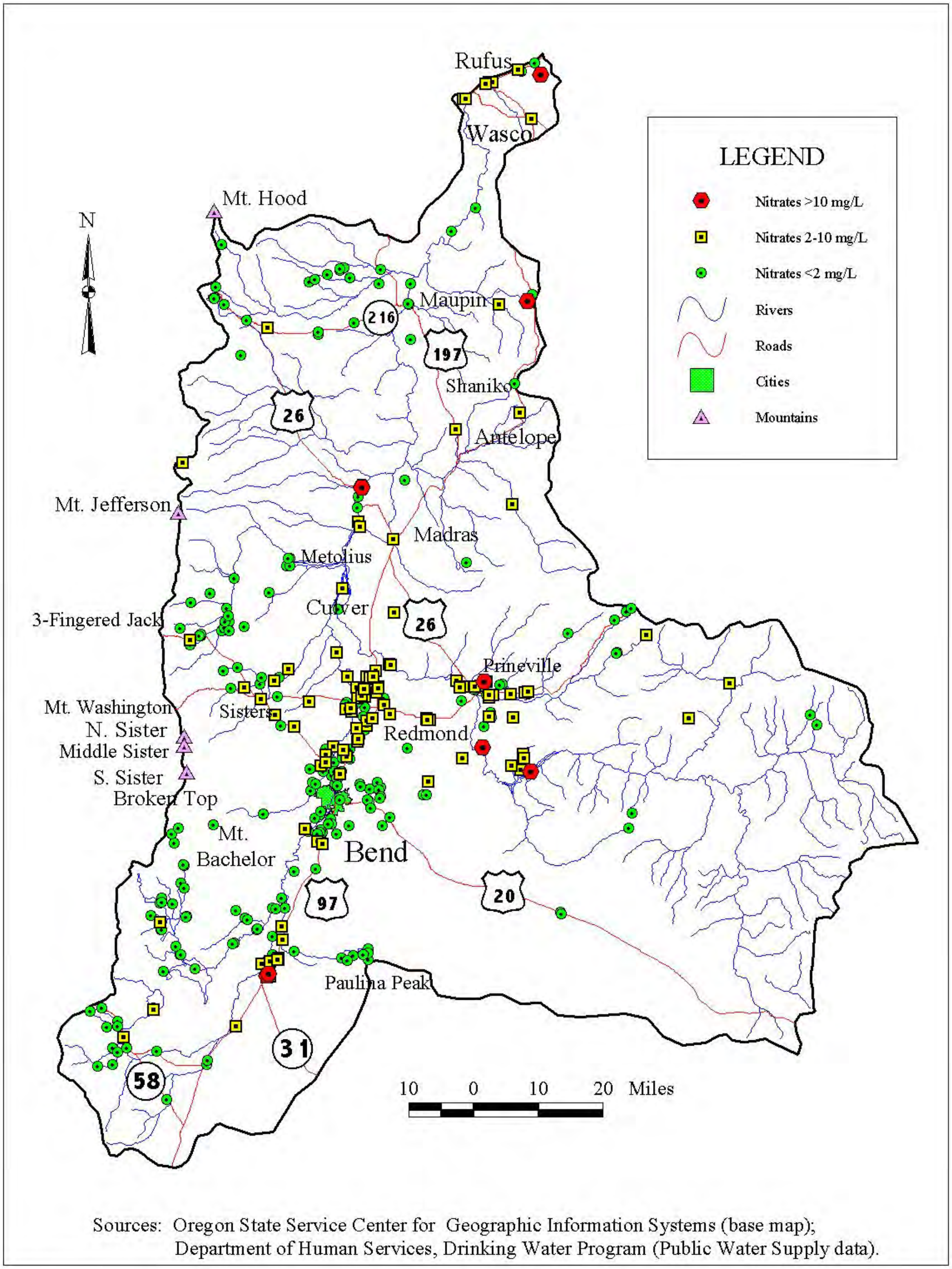
Contaminant	# of systems detected	# of Wells Over MCL	Maximum Value Detected	NPDW MCL* (mg/L)
Nitrate	360	10	12.1 mg/L	10
Bacteria	58	58	N.A.	5% positive/per month
Lead	4	4	0.0461	0.015 (Action Level)
Cadmium	1	0	0.0030	0.005
Thallium	7	6	1.000	0.002
Arsenic	4	4	0.160	0.01
Antimony	2	1	0.0060	0.006
Volatile Organic Compounds	23	2	3.5	0.005
Chromium	1	0	0.0550	0.1
Mercury	4	0	0.0017	0.002

*NPDW MCL = National Primary Drinking Water Maximum Contaminant Level (mg/L = milligrams per liter = parts per million)

Figure 11 shows the distribution of nitrates in Deschutes Basin groundwater-based PWS. The nitrate distribution uses 2 mg/L as an approximate indicator of anthropogenic influence (Department of Human Services, Drinking Water Program, Nitrate Fact Sheet, DHS Nitrate Facts).

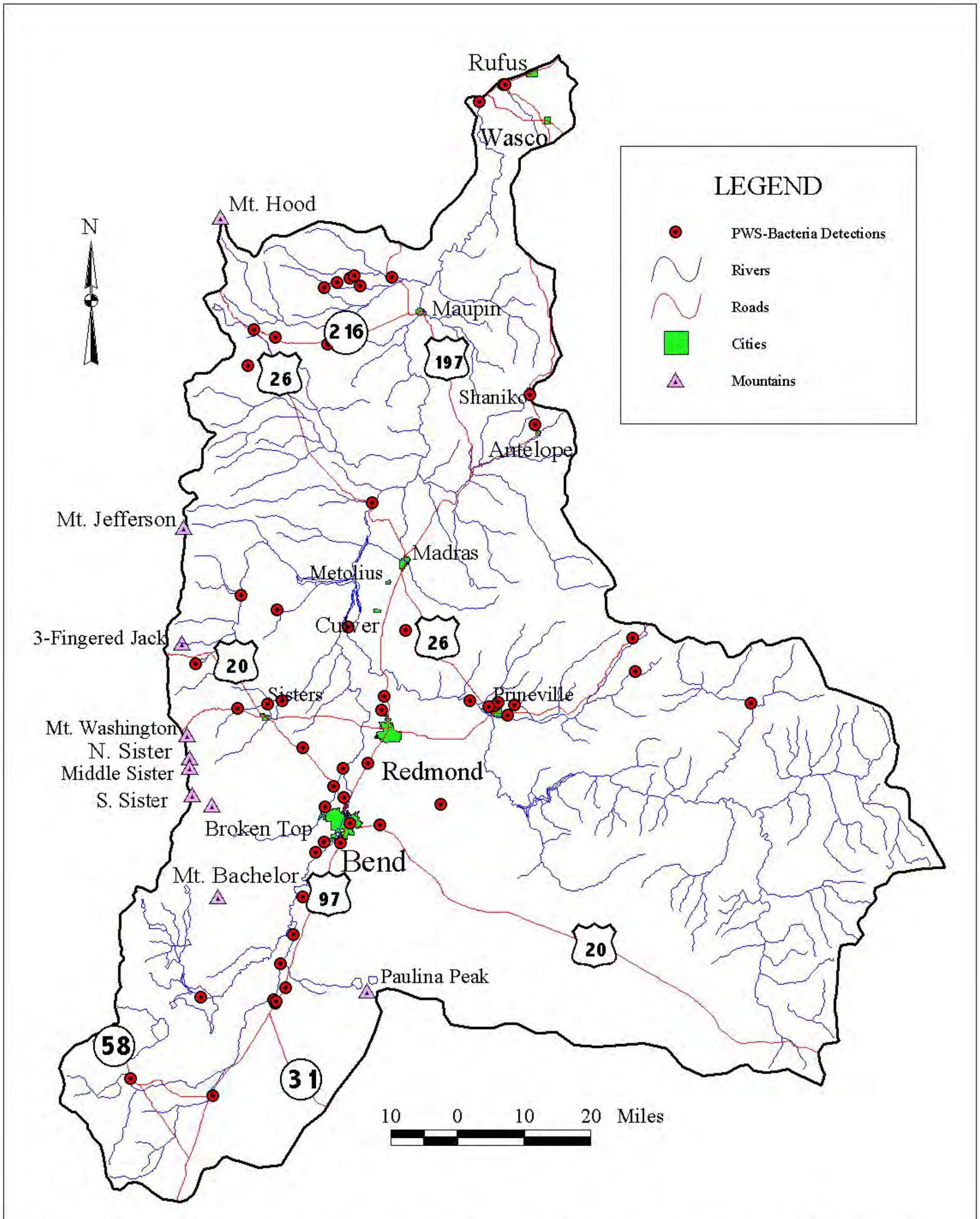
Figure 12 shows the locations of groundwater-based PWS with total coliform bacteria detections. The DHSDWP database for these systems generally covers the testing period from the present, back approximately two-and-a-half years. Some PWS have a more limited period of record, and some have no test data. The systems with no test data are not shown on the figure.

Figure 13 shows the locations of the PWS in the Deschutes Basin with other exceedances (i.e., antimony, arsenic, lead, thallium, and VOCs).



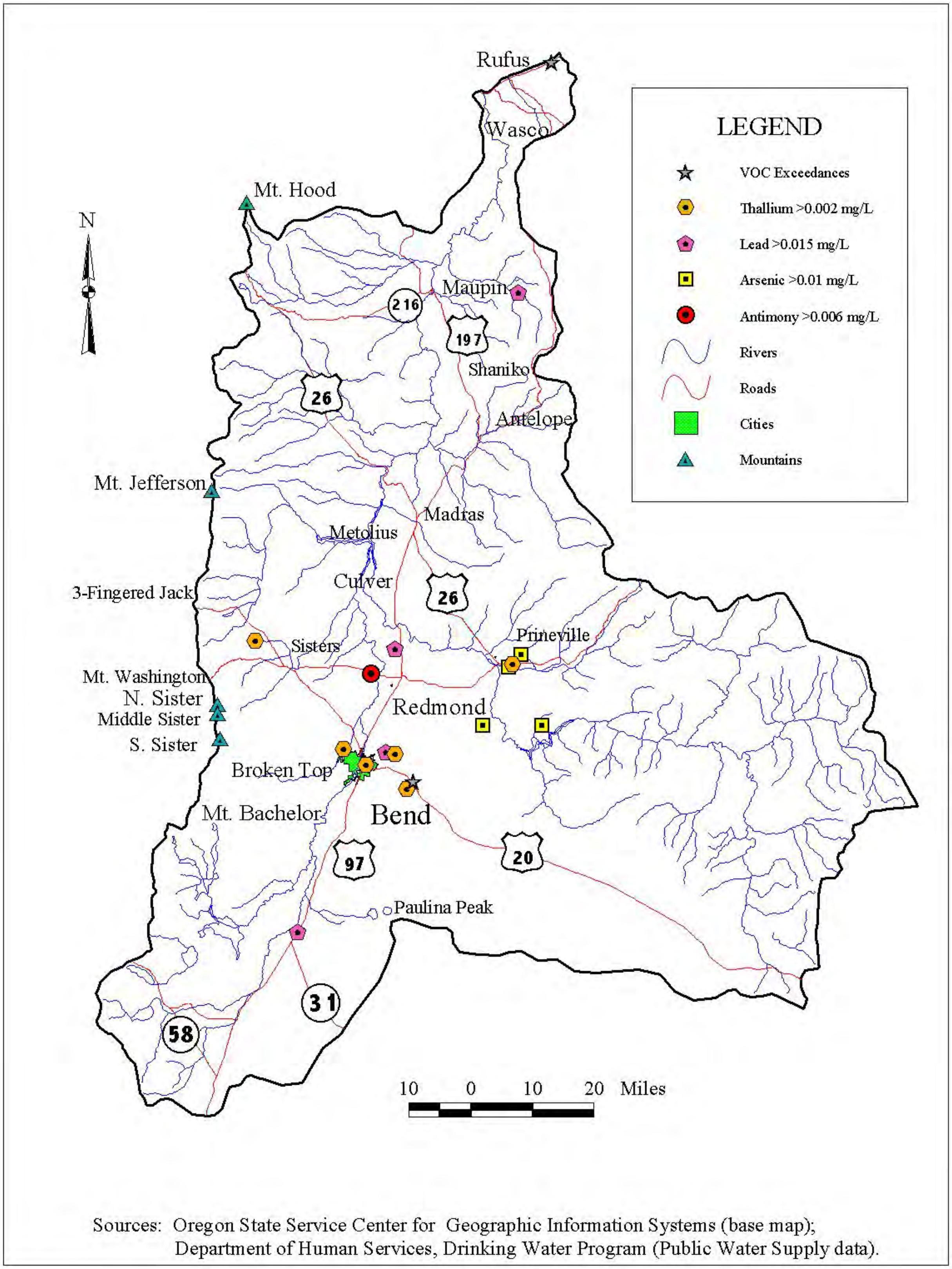
Sources: Oregon State Service Center for Geographic Information Systems (base map); Department of Human Services, Drinking Water Program (Public Water Supply data).

Figure 11. Nitrate levels in Deschutes Basin Groundwater-based Public Water Systems.



Sources: Oregon State Service Center for Geographic Information Systems (base map), Oregon Department of Human Services, Drinking Water Program (bacteria data).

Figure 12. Locations of Groundwater-based Public Water Systems with bacteria detections.



Sources: Oregon State Service Center for Geographic Information Systems (base map);
Department of Human Services, Drinking Water Program (Public Water Supply data).

Figure 13. Deschutes Basin Public Water System Exceedances other than Nitrates and Bacteria.

Area Studies

La Pine Groundwater Quality Study (1978 – 1979) - Oregon Department of Environmental Quality

Summary

Between August 1978 and January 1979, the DEQ collected groundwater samples from 46 domestic wells in the La Pine core area to determine whether there was shallow aquifer contamination in the area. Personnel from Deschutes County and the Oregon Water Resources Department assisted the DEQ with this initial sampling effort.

Forty-six wells were sampled in this study. Forty of the 46 wells were sampled once for nitrates. Three of the wells were sampled twice; once for nitrates, and once for bacteria. One well was sampled twice; both times for nitrates only. Two wells were sampled three times; both twice for nitrates, and once for bacteria.

Results

The results include the following:

- Eight of the 46 wells had nitrate levels over the drinking water standard of 10 mg/L.
- Two of these wells exceeding the standard were sampled twice for nitrates, and exceeded the standard both times.
- The maximum nitrate concentration was 25.8 mg/L, about two-and-a-half times higher than the drinking water standard.

These results led the DEQ to authorize Century West Engineering Corporation to conduct an in-depth study and analysis of the aquifer contamination problem in the La Pine area.

Table 1, Appendix 1, summarizes the sampling results from the 1978 – 1979 DEQ La Pine study.

La Pine Aquifer Management Plan (1982) - Century West Engineering Corporation

Summary

In 1978 and 1979, the DEQ collected groundwater samples from 46 domestic wells in the La Pine core area. The DEQ Laboratory analyzed these samples for nitrate and bacteria. The DEQ performed this sampling to determine whether shallow aquifer contamination was taking place. The results of the sampling showed eight of the wells had nitrate levels exceeding the drinking water standard of 10 mg/L. This led the DEQ to authorize Century West Engineering Corporation to conduct an in-depth water quality sampling and analysis of the aquifer in the La Pine area.

The EPA provided grant money and Deschutes County contributed money to fund the project. The DEQ authorized the work in an interagency agreement with Deschutes County, and in August of 1980 Century West initiated the work.

The DEQ identified 10 beneficial uses of groundwater in the study area. The highest of these beneficial uses was domestic water supplies. The DEQ recommended a 5 mg/L nitrate concentration planning limit in undeveloped areas, to be used in determining suitable waste system densities for new subdivisions. As a condition of approval for some on-site waste disposal systems, the DEQ required proof that a 5 mg/L nitrate concentration in the aquifer would not be exceeded.

As part of the aquifer study, Century West installed monitoring wells in 1981. Century West also used monitoring wells that Sweet, Edwards & Associates installed in 1980. This sampling addressed the following three primary goals:

1. To define baseline shallow aquifer quality,
2. To observe what additional contaminants might exist in concentrations which could jeopardize water supplies, and
3. To check whether or not sewage indicators, such as chloride and sulfate, showed the same geographic trends as the nitrates.

The initial Century West sampling took place in the winter of 1981. Century West conducted resampling in April of 1982, when the depth to the water table below ground level had risen about three feet from the previous wintertime sampling.

Results

- Century West resampled selected wells from the initial 1978 – 1979 DEQ survey, and the results showed no significant change. The wells with low nitrate levels showed continued low levels, and the wells with high nitrate levels showed continued high levels. This confirmed the continued presence of high nitrate groundwater in the La Pine core area.
- The results of April 1982 showed no presence of bacteria, and lower nitrate levels. This was possibly due to increased dilution in the aquifer, resulting from the rising water table.
- Nitrate levels tended to be high in areas with a high density of on-site septic systems, and low in areas where no development had taken place. This supported the theory that the main source of nitrates was domestic sewage.
- The data did not show the presence of a continuously expanding plume of groundwater contamination in the core area.
- During this study Century West also conducted surface water sampling. This sampling showed no evidence of surface water contamination from contaminated groundwater.

Century West based their study on a 20 year projected growth need for the area. They concluded that present and future nitrate loading was not expected to negatively affect the aquifer or aquifer discharge areas.

Although the domestic water supply in the La Pine area is primarily from a shallow, alluvial aquifer, domestic water is also derived from deeper wells in the area. This water comes from deep sediments or basalt. Century West included water quality information from several deep wells in the area. Various private laboratories performed the testing. The water quality data from the deep wells is from the Bend office of the Oregon Department of Human Services. Table 2, Appendix 1, summarizes the sampling results from the 1982 La Pine study.

Located about 7 miles south of the La Pine study area is the Shields Septic Disposal site. La Pine residents were concerned that activities at this site were affecting La Pine area groundwater. DEQ data indicates local impacts, but at low levels, suggesting no regional influence on the shallow La Pine aquifer. Table 3, Appendix 1, summarizes this data.

A major product of Century West's Aquifer Management Plan for the area was a set of management alternatives and recommendations designed to protect the beneficial uses of the groundwater. A full discussion and description of these recommendations can be found in the Aquifer Management Plan (Century West Engineering, 1982).

Prineville Groundwater Study (1993) - *Oregon Department of Environmental Quality*

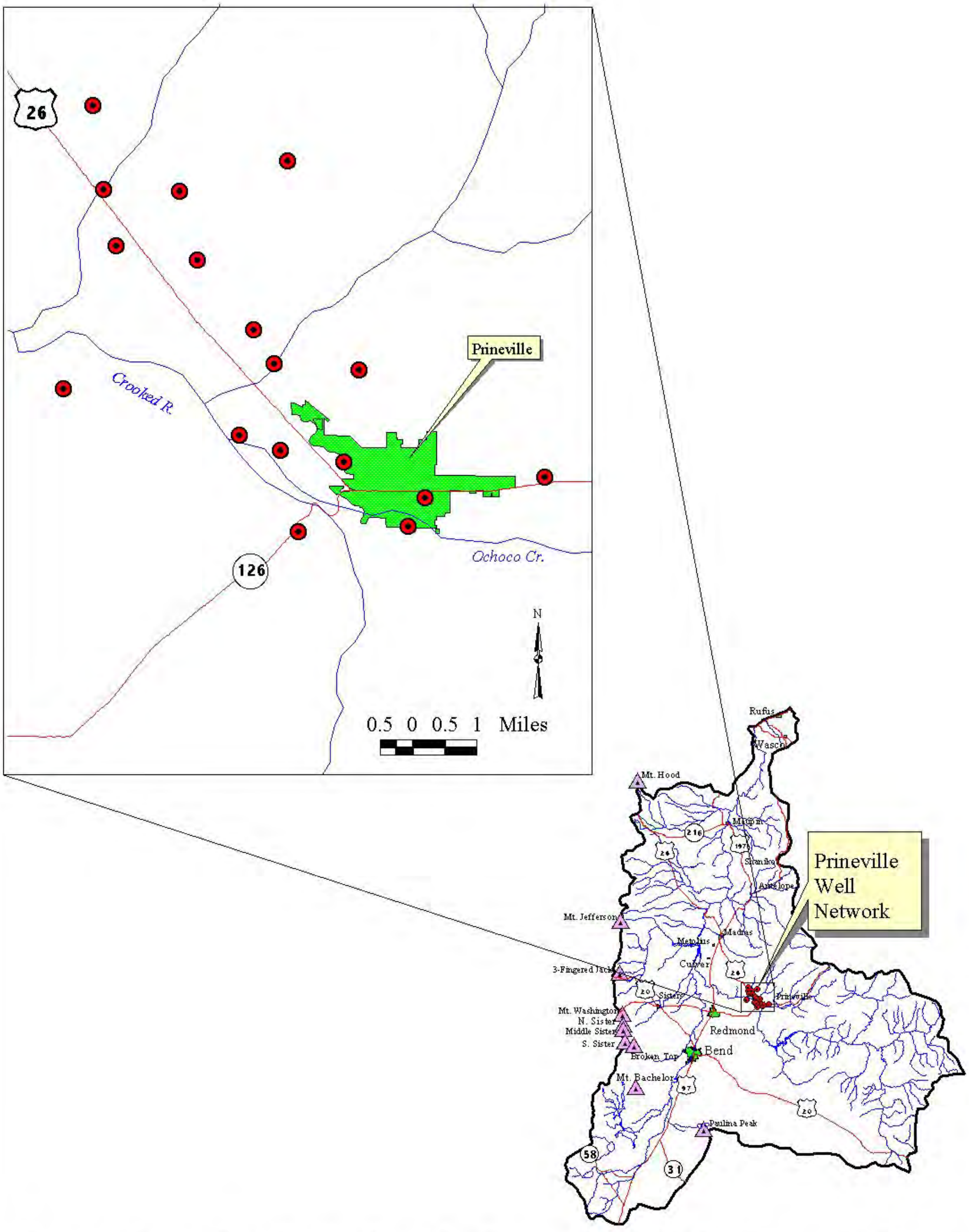
Summary

As part of its ambient groundwater quality monitoring program, the DEQ collected water quality samples from 17 private, domestic wells in the Prineville area in the summer of 1993. The DEQ analyzed the samples for a full suite of constituents, including VOCs, pesticides, metals, common ions, nutrients, and physical parameters. The Oregon Department of Agriculture (ODA) laboratory conducted the pesticide analyses, while the DEQ Lab analyzed all remaining constituents.

Appendix 2 lists the method detection limits and applicable drinking water standards for VOCs (Table 1), individual pesticides (Table 2), and metals, nutrients, and physical parameters (Table 3). The pesticides included in the five screening analyses and their method detection limits are in Table 4 of the same appendix.

To minimize health risks, the DEQ notified owners of drinking water wells of any drinking water standard exceedances as soon as the data was available.

Figure 14 shows the Prineville well network location in the Deschutes Basin, and a close-up of the well sample sites.



Sources: Oregon State Service Center for Geographic Information Systems (basin map), Oregon Department of Environemntal Quality (Prineville well network data).

Figure 14. Location of the Prineville Well Network in the Deschutes Basin.

Results

Table 2 summarizes the results from the 1993 sampling event. Table 4, Appendix 1, presents all analytical data from the testing.

The results include the following:

- Nitrate[1] was detected in all 17 wells. Five wells (29%) exceeded the 10 mg/L Maximum Contaminant Level (MCL), while 11 of the 17 wells had nitrate levels at or above 2 mg/L, indicative of anthropogenic influences.
- Atrazine was detected in one well, at a concentration below the drinking water standard (0.003 mg/L).
- Toluene was detected in one well below the MCL of 1 mg/L.
- Barium was detected in 12 wells, all below the drinking water standard of 2 mg/L.
- Arsenic was detected in four wells, three of which were at or slightly above the drinking water standard of 0.01 mg/L.
- Copper was detected in five wells, all of which were below the drinking water Action Level of 1.3 mg/L.

Figure 15 shows the distribution of nitrate detections throughout the study area.

Data from DEQ's sampling are available in LASAR through the internet at: DEQ Lab LASAR, and can be retrieved using Prineville Groundwater as the sampling event name.

Table 2. Prineville Groundwater Study (1993).

Contaminant	No. of wells detected out of 17 wells	Average[*] Concentration (mg/L)	Maximum Concentration (mg/L)	Detection Limit (mg/L)	NPDW MCL[**] (mg/L)	Number of Wells Over MCL
Nitrate	17	7.34	23	0.02	10	5
Atrazine	1	0.0001	0.0001	0.0001	0.003	0
Toluene	1	0.0035	0.0035	0.0005	1	0
Arsenic	4	0.010	0.014	0.006	0.01	3
Copper	5	0.06	0.09	0.02	1.3 (Action Limit)	0
Barium	12	0.04	0.05	0.03	2	0

[*] Average concentration calculated for wells with detectable contaminant levels and may include multiple samples.

[**] NPDW MCL = National Primary Drinking Water Maximum Contaminant Level (mg/L = milligrams per liter = parts per million)

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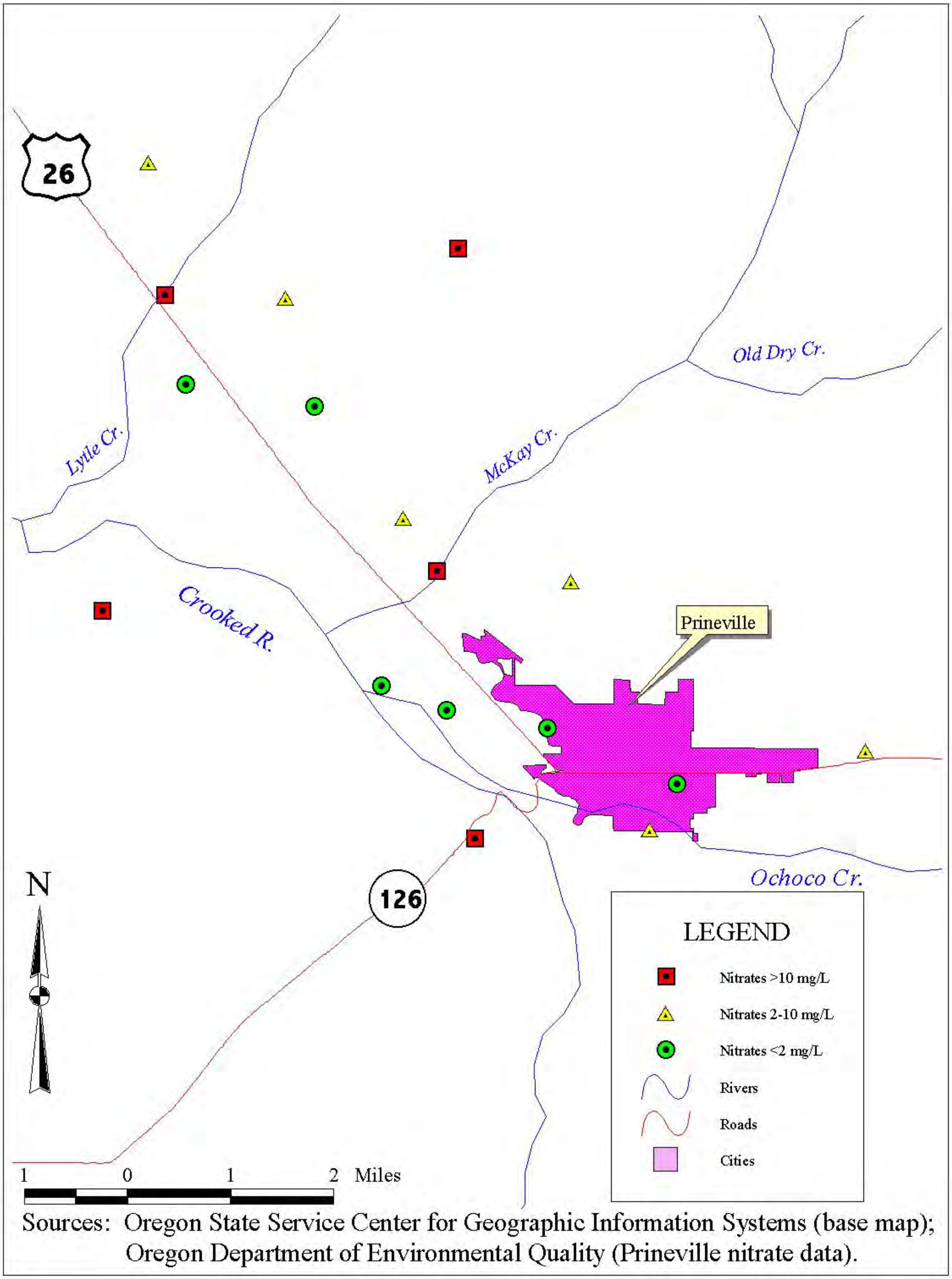
[1] Nitrate was analyzed as nitrate plus nitrite as nitrogen, and is assumed to be primarily in the form of nitrate.



Sources: Oregon State Service Center for Geographic Information Systems (base map); Oregon Department of Environmental Quality (Prineville nitrate data).

Figure 15. Nitrate distribution, from the Prineville Groundwater Study (1993).

La Pine Groundwater Study (1993) - Oregon Department of Environmental Quality

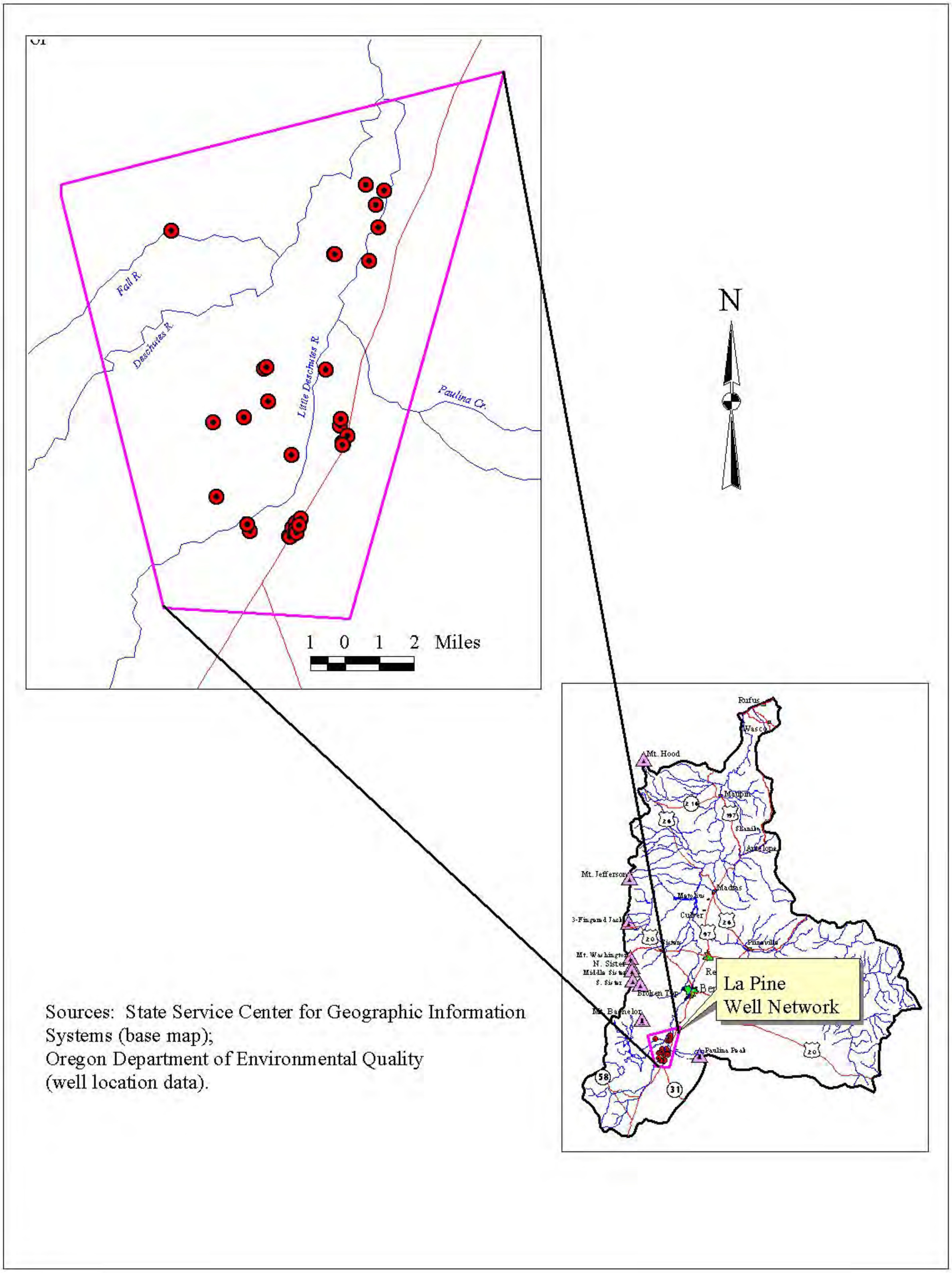
Summary

In May and July of 1993, as part of its Ambient Groundwater Quality Monitoring Program, the DEQ conducted a sampling event in the La Pine area. This sampling event collected and tested the groundwater quality from 39 drinking water wells. The DEQ analyzed the samples for a full suite of constituents, including volatile organic compounds (VOCs), pesticides, metals, common ions, nutrients, and physical parameters. The Oregon Department of Agriculture (ODA) laboratory analyzed the pesticide samples, while the DEQ Lab analyzed all remaining constituents.

The method detection limits and applicable drinking water standards are listed in Appendix 2 for VOCs (Table 5), individual pesticide (Table 6), and metals, nutrients, and physical parameters (Table 7). The pesticides included in the five screening analyses and the method detection limits are also listed in Appendix 2 (Table 4).

To minimize human health issues due to contaminated wells, the DEQ notified owners of drinking water wells of any drinking water standard exceedances as soon as the data was released.

Figure 16 shows the locations of the La Pine well network in the Deschutes Basin, and a close-up of the well locations.



Sources: State Service Center for Geographic Information Systems (base map);
Oregon Department of Environmental Quality (well location data).

Figure 16. Location of the 1993 La Pine Well Network in the Deschutes Basin.

Results

The results include the following:

- Nitrate[2] was detected in 36 wells. Four wells (10%) exceeded the 10 mg/L MCL, while 19 wells out of a 39 well network (49%) had nitrate levels at or above 2 mg/L, indicating anthropogenic influences.
- Atrazine was detected in four wells; however all the detections were below the drinking water standard (0.003 mg/L).
- Dicamba was detected in one well at 0.0035 mg/L. No MCL exists for Dicamba.
- 1-2,Dichloroethane was detected in one well at 0.0318, above the MCL of 0.005 mg/L.
- Barium was detected in one well, below the drinking water standard of 2 mg/L..
- Lead was detected in one well, below the Action Level of 0.015 mg/L.
- Copper was detected in 10 wells, all of which were below the Action Level of 1.3 mg/L.
- Various VOCs were detected in seven wells. No MCLs exist for the particular VOCs detected.

Table 3 summarizes the results from the 1993 sampling event. Table 5, Appendix 1, details all analytical results from the testing.

Table 3. La Pine Groundwater Study (1993).

Contaminant	No. of Wells Detected out of 39 Wells	Maximum Concentration (mg/L)	Detection Limit (mg/L)	NPDW MCL* (mg/L)	Number of Wells Over MCL
Nitrate	36	16	0.02	10	4
Atrazine	4	0.00108	0.0001	0.003	0
Dicamba	1	0.0035	0.0002	N.A.	N.E.
Lead	1	0.009	0.0030	0.015	0
1-2,Dichloromethane	1	0.0318	0.0005	0.005	1
Various VOCs	7	various	various	N.A.	N.E.
Barium	1	0.05	0.00010	2	0
Copper	10	0.17	0.00030	1.3	0

*Average concentration calculated for wells with detectable contaminant levels and may include multiple samples.
**NPDW MCL = National Primary Drinking Water Maximum Contaminant Level (mg/L = milligrams per liter = parts per million).
N.E. = Not Established.

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[2] Nitrate was analyzed as nitrate plus nitrite as nitrogen, and is assumed to be primarily in the form of nitrate.

La Pine Groundwater Quality and Modeling Study (1994-1995) - Oregon Department of Environmental Quality

Summary

In 1994/1995 the DEQ conducted another groundwater study in the La Pine area. Deschutes County then requested the DEQ assess residential development effects on groundwater quality. With the data, the DEQ performed computer modeling to evaluate groundwater flow and nitrate fate and transport. The model was a 2-D numerical cross-sectional nitrate fate and transport model (Flow-MODFLOW, Transport- MT3D96). The model focused on two build-out scenarios:

1. Existing conditions, as of 1994, and
2. Full build-out of all platted lots.

For conceptual model development, various estimates of inputs, such as aquifer hydraulic conductivity and recharge, were required. Best estimates were made using the following available data:

- Well log pumping data using TGUESS,
- 1982 Century West Engineering Corporation pump test data, and
- USGS pump test and conductivity estimates for the Upper Deschutes Basin.

A recharge rate of 5 - 7 in/year was assumed for the aquifer. The model assumed the following nitrate loadings:

- 40 mg/L for a standard on-site distribution system,
- 29 mg/L for a sand filter distribution system, and
- 40 mg/l for a pressure distribution system.

Results

Figure 17 shows the nitrate concentration contours, based on the DEQ 1994 - 1995 sampling data from 120 wells. This figure is from the Work Plan (see the following web site for more details: http://www.deq.state.or.us/wq/onsite/lapine.htm).

Model predictions underline progressive groundwater contamination from nitrate, with development of the existing lots. Moreover, the model predicts that nitrate-nitrogen concentration will likely exceed the drinking water standard of 10 mg/l within the next 10 to 20 years under the full build-out scenario.

The field work performed prior to model development included water levels, physical parameters, and field nitrate determinations. Table 6, Appendix 1, details all analytical results from the testing.

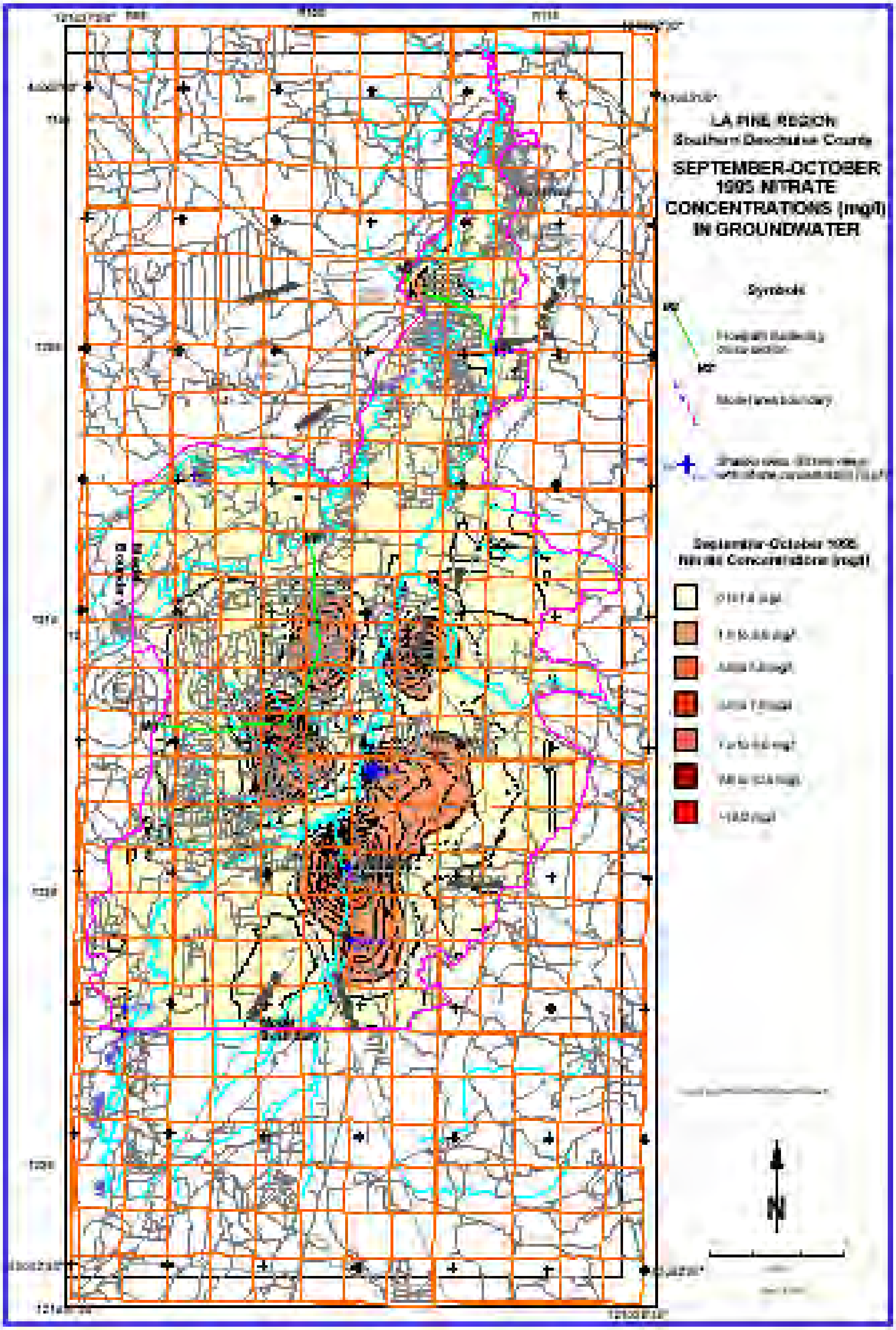


Figure 17. Nitrate concentration contours (1995 DEQ data).

La Pine On-Site Demonstration Project (1999) – Oregon Department of Environmental Quality

Summary

Previous groundwater quality studies in the La Pine area had shown the sole source aquifer was vulnerable to contamination. The studies had also shown some parts of the aquifer were already contaminated with nitrates. The modeling work the DEQ did in 1995 showed that if nothing was done to change development practices in the area, then aquifer nitrate levels would exceed the federal safe drinking water standard.

With a grant from the EPA, the DEQ, in cooperation with the US Geological Survey and Deschutes County Environmental Health Division, began a five-year on-site demonstration project, beginning in 1999. The project's objective was to protect the La Pine sub-basin aquifer water quality, while allowing development to occur. This is to be accomplished through a holistic approach, incorporating the following factors:

- Implement innovative denitrification technologies.
- Apply groundwater flow, and nitrate fate and transport knowledge.
- Determine appropriate development density through lot size optimization modeling, based on denitrification system study results.

The project management established the following eight tasks to achieve the project objective:

1. Establish 200 or more on-site systems.
2. Establish 130 monitoring wells.
3. Establish an on-site maintenance structure.
4. Develop funding for on-site system repair and/or replacement.
5. Collect and analyze data from on-site systems and the groundwater monitoring network.
6. Analyze system effluent and groundwater samples.
7. Conduct 3-D groundwater flow and nitrate fate and transport modeling, and lot size optimization modeling for nitrate loading reduction.
8. Prepare progress and final reports.

The project tested 15 different types of systems, using three control systems (standard, pressure, and sand filter). Each system had a "drain" monitoring well located in proximity to the system's discharge point. Each system had between one and five monitoring wells, located some distance from the drain monitoring well. The systems were typically sampled between monthly, bimonthly, and quarterly. Table 7, Appendix 1 details the sampling frequency and testing results data from the monitoring wells used for computing statistics.

Figure 18 shows the study area location. This figure is from the Work Plan (see the following web site for more details: http://www.deq.state.or.us/wq/onsite/lapine.htm).

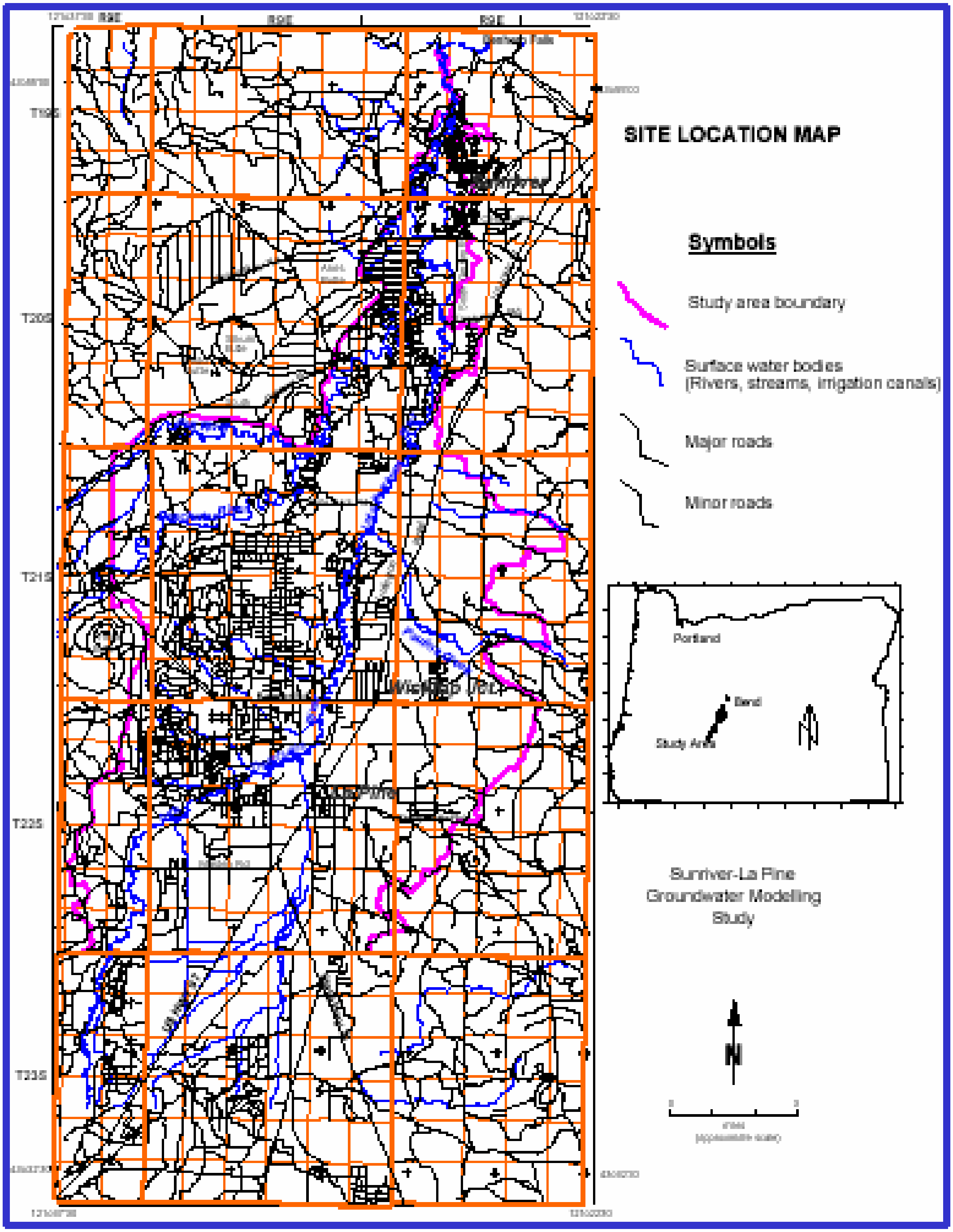


Figure 18. Location of 1999 La Pine On-Site Demonstration Study Area.

Results

Water level measurements yielded horizontal and vertical groundwater flow information. Using this information, the groundwater flow and nitrate transport model showed if nitrogen loading to the aquifer remained at present (1999) levels, peak nitrate concentrations in the aquifer would not occur for 30 years. However, the population forecast shows a doubling of the nitrate loading by the year 2020. The modeling predicts that this will result in groundwater nitrate concentrations exceeding the drinking water standard over large areas.

These predictions are unsettling to many people and entities, not the least of which is Deschutes County. The County is pursuing the following two main options to manage groundwater quality in the area:

1. Reduce housing density, and
2. Reduce nitrate loading, using Decentralized Wastewater Treatment Systems (DWTS).

Deschutes County contracted with foreign and domestic sources to provide innovative DWTS for testing. After five years of testing, the County found the DWTS are capable of reducing nitrate concentrations by as much as 96 percent. The County designed numerous scenarios incorporating denitrifying DWTS and transferable development credits (TDC). The best scenario used a system with a 2 mg/L performance level. This scenario predicted no areas with nitrate concentrations exceeding the drinking water standard. All scenario simulations showed groundwater nitrate concentrations would peak within 20 to 50 years, and then decline to equilibrium levels within 100 years.

Maintaining a healthy economy with these water quality issues poses a complex decentralized wastewater management and land-use planning problem for Deschutes County. To help the County solve these problems, a Nitrate Loading Management Model (NLMM) was developed. This model uses optimization techniques designed to predict the aquifer system's sustainable maximum nitrate loading capacity, while groundwater nitrate concentrations and nitrate discharge to streams are maintained at desired levels. The optimization method used to solve the NLMM is based on the response-matrix technique. This technique requires calculating many response functions, based on many simulations.

The optimization approach requires decision-makers and stakeholders to quantify goals and objectives. The management objective of the NLMM reflects the following goals:

1. Allow as many existing lots to be developed as possible, and
2. Minimize the number of existing DWTS that need to be upgraded.

Since costs are associated with reducing loading through prohibiting lot development, or replacing existing DWTS, the management objective becomes minimizing the cost of meeting water quality goals. The management objective also requires decision-makers and stakeholders to incorporate the following concepts:

1. Set values on water quality constraints reflecting regulatory requirements, and

2. Agree on desirable economic and community conditions.

The County can use the management model to support decisions quantifying the relationship between water quality constraints and optimal solutions. The model included a cost variable to account for differences in reducing nitrate loading from existing and future homes.

A potentially cost effective alternative to constraining nitrate concentrations in the aquifer system’s shallow part involves deepening wells or developing local community water systems.

With these tools Deschutes County now has options from which to choose an optimal management strategy.

Overall Status of Deschutes Basin Groundwater

Nitrate

Deschutes Basin studies have found areas with nitrate in the groundwater. Nitrate levels above 2 mg/L indicate anthropogenic activities (DHS Fact sheet), and have adversely affected the groundwater. Nitrate sources include dispersed non-point sources such as agricultural activities and on-site septic systems, and point sources generating nutrient rich waste products.

Some Public Water Systems (PWS) in the region have reported nitrate levels between 2 and 10 mg/L. Ten PWS in the Deschutes Basin have reported nitrate levels above the Maximum Contaminant Level (MCL, 10 mg/L). For domestic wells sampled as part of real estate transactions, two percent of the tests exceeded the MCL.

In local area studies, elevated nitrate was found in the Prineville area. Nitrate was above the MCL in five wells out of a network of 17 wells (29%).

In the La Pine area, four wells of a 39 well network (10%) exceeded the MCL. Nineteen of the wells (49%) had nitrate levels at or above 2 mg/L. This indicates anthropogenic activities have adversely affected the groundwater quality.

Bacteria

Positive groundwater bacteria detections may indicate contamination from non-point sources, including on-site septic systems, or point sources, including facilities handling or disposing of septage or manure. Bacteria from well water can also be due to poor well construction and maintenance practices.

On a regional scale, the domestic well real estate transaction data collected throughout the Deschutes Basin counties showed 190 tests out of 4,235 were positive for bacteria. Fifty-eight PWS also reported positive tests for bacteria.

Toxics – Pesticides

No PWS reported any pesticide detections. One well in the Prineville area had the pesticide Atrazine in it. However, the concentration was below the drinking water standard. Four wells in the La Pine area had Atrazine detected in them, none of which exceeded the drinking water standard. One La Pine well had the pesticide Dicamba detected in it at a concentration of 0.0035 mg/L (no standard exists for Dicamba).

Toxics – Volatile Organic Compounds

Twenty-three PWS in the region reported detections of VOCs. Only two PWS detected VOCs above their individual Maximum Contaminant Level (MCL). One well in the Prineville area had Toluene in it, but below the MCL. Finally, seven wells in the La Pine area had VOCs detected in them, one of which, 1-2,Dichloromethane, exceeded the MCL.

Toxics - Metals

Four PWS reported lead exceeding the Federal Action Level of 0.015 mg/L. Seven PWS reported thallium, including six exceedances of the MCL (0.002 mg/L). Four PWS reported arsenic above the MCL of 0.01 mg/L. Antimony was detected in two PWS, and exceeded the MCL (0.006 mg/L) in one of those wells. Cadmium and chromium were detected in one PWS, but did not exceed the MCLs. Four PWS detected mercury, none of which exceeded the MCL.

Arsenic was detected in four Prineville area wells, three of which exceeded the MCL. Twelve Prineville area wells had barium in them, all of which were below the MCL. Copper was detected in five Prineville area wells, none of which exceeded the MCL.

One La Pine area well had lead in it, below the Action Level. One well had barium in it, below the MCL. Ten wells had copper in them, none of which exceeded the Action Level.

POLLUTANT SOURCES

Overview

Various state and federal programs regulate pollution sources in Oregon. Point sources are confined or discrete pollution sources where contaminants can enter into public waters (OAR 340-040-0010(14)). Nonpoint sources are diffuse or unconfined pollution sources (OAR 340-040-0010(12)). The state and federal regulatory goal is to prevent or minimize adverse effects on groundwater quality from surface activities. Several types of point sources in the Deschutes Basin are discussed below.

Waste Dischargers

The DEQ regulates waste discharges through permits. Permit types include the following:

- National Pollutant Discharge Elimination System (NPDES) - These permits must meet Federal Water Pollution Control Act requirements and procedures (OAR 340-045-0010(9)). NPDES permits generally cover all discharges, whether direct or indirect, to surface waters of the United States. NPDES permits cover direct discharges into a river or stream, or indirect discharges into a drain or ditch conveying wastewater to a river or stream, and also covers discharges to land.

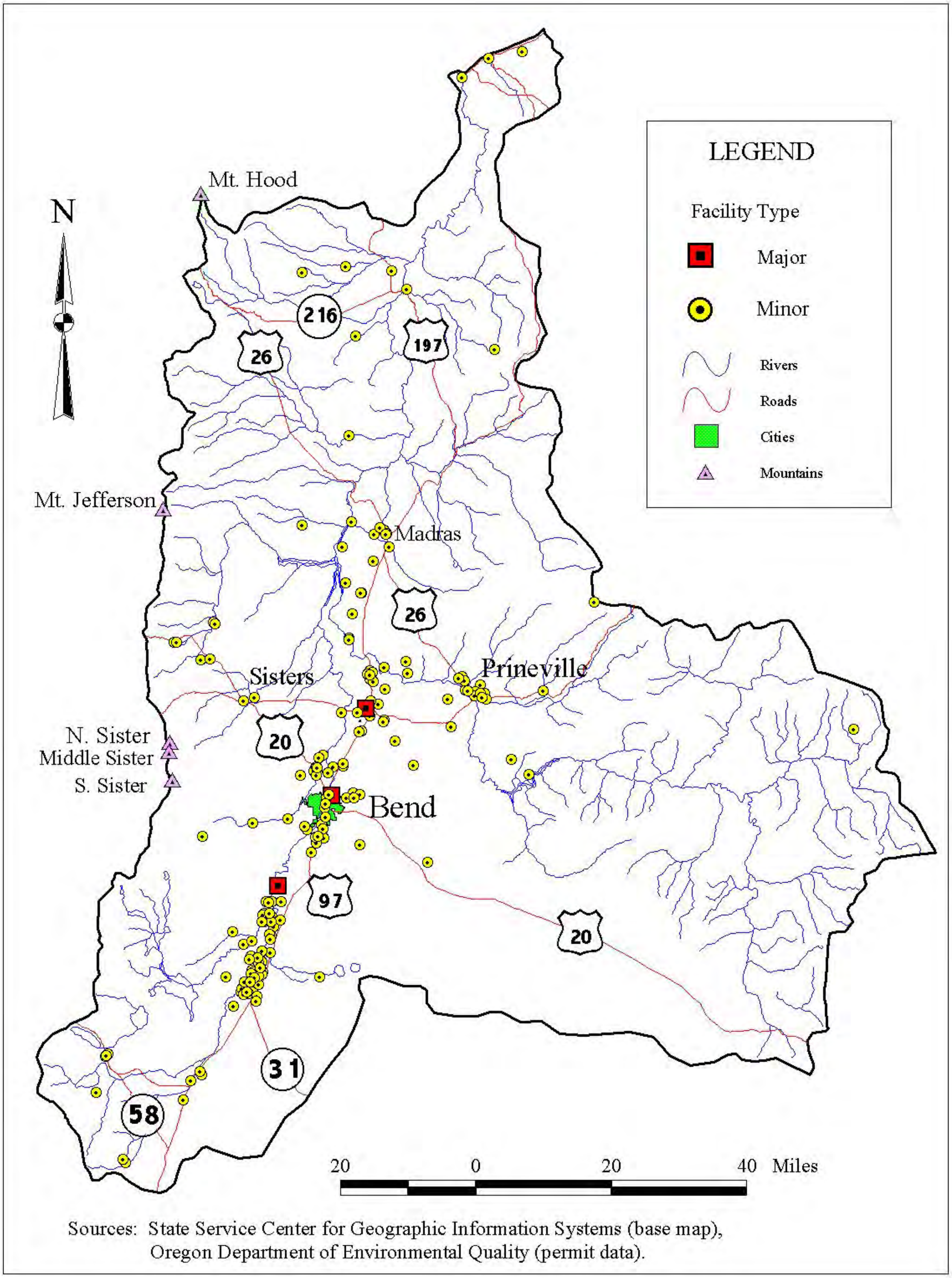
- Water Pollution Control Facilities (WPCF) - These permits regulate disposal system construction and operation with no discharge to navigable waters (340-045-0010(12)). State requirements and procedures (OAR 340-045 or OAR 340-071) distinguish these facilities from those discharging to navigable waters. The DEQ issues WPCF permits for discharges not covered by an NPDES permit. WPCF permitted facilities may discharge wastewater onto land through irrigation, into drain fields, or into lagoons and holding ponds.

NPDES and WPCF permitted facilities discharge a variety of wastewater including sewage, pulp and paper waste, food processing waste, smelting/refining waste, cooling water, industrial storm water, mining waste, and municipal wastewater.

The DEQ has regional offices in various locations around the state. Eastern Region offices in The Dalles and Bend manage permits within the Deschutes Basin. Information on NPDES and WPCF permits is available on-line at the following web site:

http://www.deq.state.or.us/wq/SISData/FacilityHomenew.asp.

Figure 19 on the next page shows the locations of 239 facilities with active permits in the Deschutes Basin. Three of these facilities are major permits handling potentially high pollutant loads or serving a large number of people. For example, the facility in Bend is a sewage treatment plant, permitted to process between 5 and 10 million gallons of effluent per day.



Sources: State Service Center for Geographic Information Systems (base map), Oregon Department of Environmental Quality (permit data).

Figure 19. Locations of Permitted Waste Discharge Facilities, Deschutes Basin, Oregon.

Underground Injection Control (UIC)

The DEQ Underground Injection Control (UIC) program regulates subsurface waste injection to protect groundwater quality. A UIC is any system, structure, or activity that is created to place fluid below the ground or sub-surface. Common underground injection systems or activities in Oregon include the following:

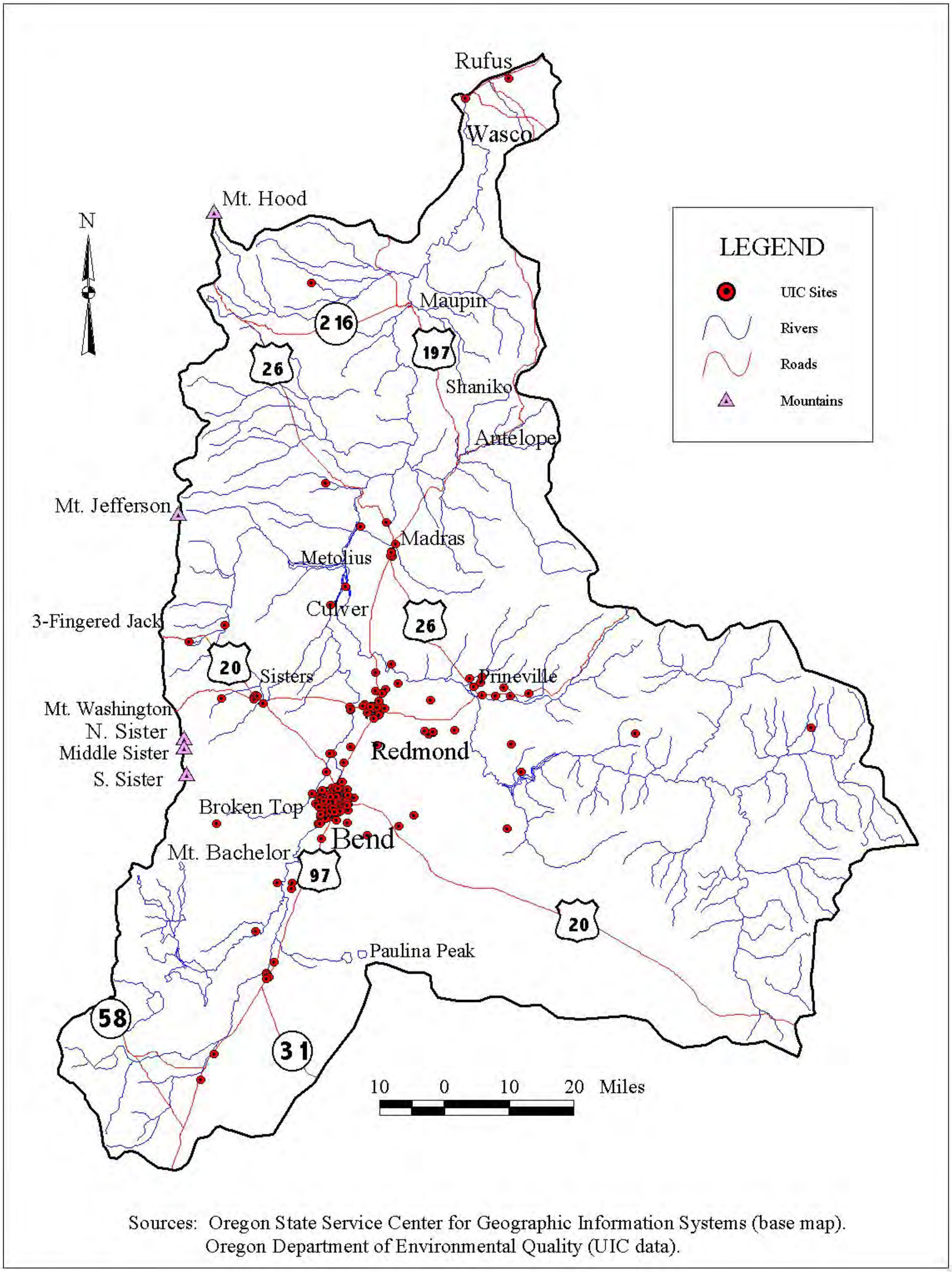
- Stormwater systems: typical designs include but are not limited to sumps, infiltration galleries, drywells, trench drains, and drill holes.
- Domestic onsite septic systems and cesspools that serve more than 20 people or have a design capacity of 2,500 gallons per day or more.
- All sewage drill holes.
- Industrial/commercial process and wastewater disposal (includes drainfields of any size).
- Cooling water return flows.
- Aquifer storage and recharge.
- Aquifer remediation systems.
- Geothermal heat pump re-injection systems.
- Motor vehicle waste (floor drains, auto drains).
- Agricultural drainage.

Until the 1980s, virtually all residences and businesses discharged their sewage into waste disposal wells. These systems were composed of a septic tank and a drilled well. The well depth was usually shallow, and was drilled downward until a cavern or other void was encountered. In 1969, due to concern for groundwater quality effects from sewage disposal, the Environmental Quality Commission adopted certain rules to force central Oregon cities to install centralized sewerage facilities to replace the waste disposal wells. Some waste disposal wells are still in operation outside sewer service boundaries, but their numbers are believed to be relatively small. Current administrative rules prohibit constructing new sewage disposal wells.

Most developed areas of central Oregon discharge stormwater into the ground through older drill holes and dry wells. These are currently common stormwater disposal methods. The potential threat to groundwater quality from current stormwater disposal practices remains a concern. However, no evidence exists to show these practices have negatively impacted water wells.

Disposal practices releasing wastewater directly into the ground can pollute groundwater and surface water if not properly designed, sited, and operated. This is one reason the DEQ monitors underground injection and requires registration of all Oregon injection systems.

The DEQ maintains a database of known UIC systems. This database is available at http://www.deq.state.or.us/wq/groundwa/UIChome.htm. The current database shows 4002 injection systems at 201 facilities in the Deschutes Basin. Figure 20 is a map of the Deschutes Basin showing the locations of all individual UIC injection systems having available latitude/longitude coordinate information.



Sources: Oregon State Service Center for Geographic Information Systems (base map).
Oregon Department of Environmental Quality (UIC data).

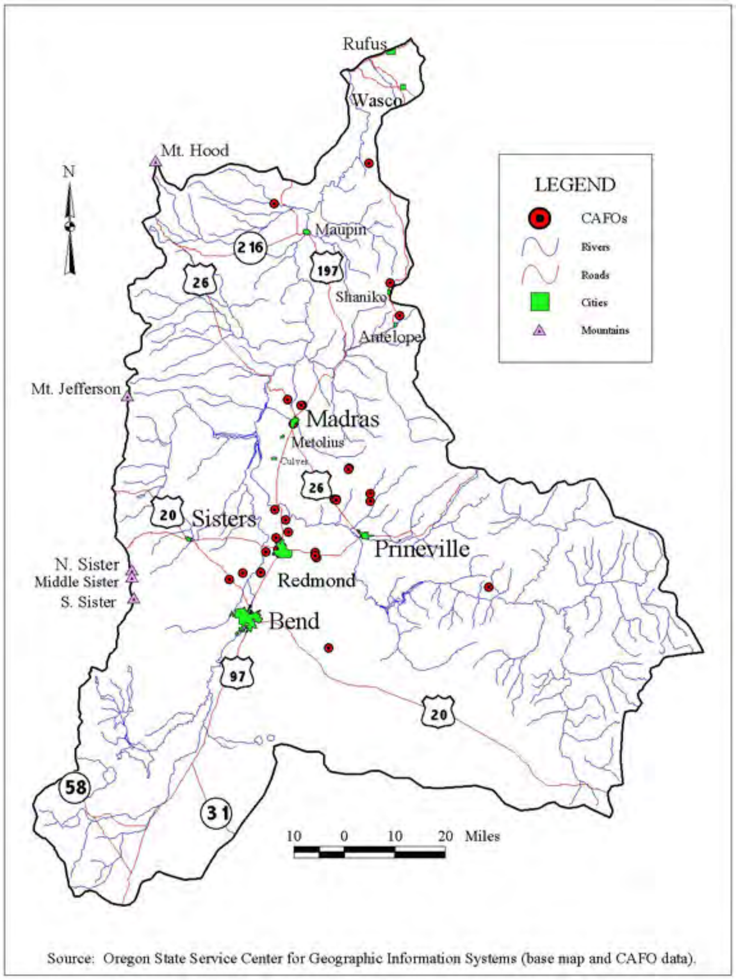
Figure 20. Underground Injection Systems in the Deschutes Basin.

Confined Animal Feeding Operations (CAFOs)

The Oregon Department of Agriculture (ODA), in conjunction with the DEQ, reviews applications and issues wastewater permits for Confined Animal Feeding Operations (CAFOs). This includes reviewing animal waste management system plans and specifications for animal waste control facilities. The types of CAFO facilities include the following:

- Production areas such as animal confinement areas;
- Manure storage areas such as lagoons, runoff ponds, storage sheds, stockpiles, and liquid impoundments; and
- Waste containment areas such as settling basins.

The waste management systems may also include land application areas. Without proper waste containment and processing systems, CAFOs can concentrate and introduce nitrate and bacterial contamination into underlying groundwater aquifers. Figure 21 shows the locations of the 34 permitted CAFOs in the Deschutes Basin.



Source: Oregon State Service Center for Geographic Information Systems (base map and CAFO data).

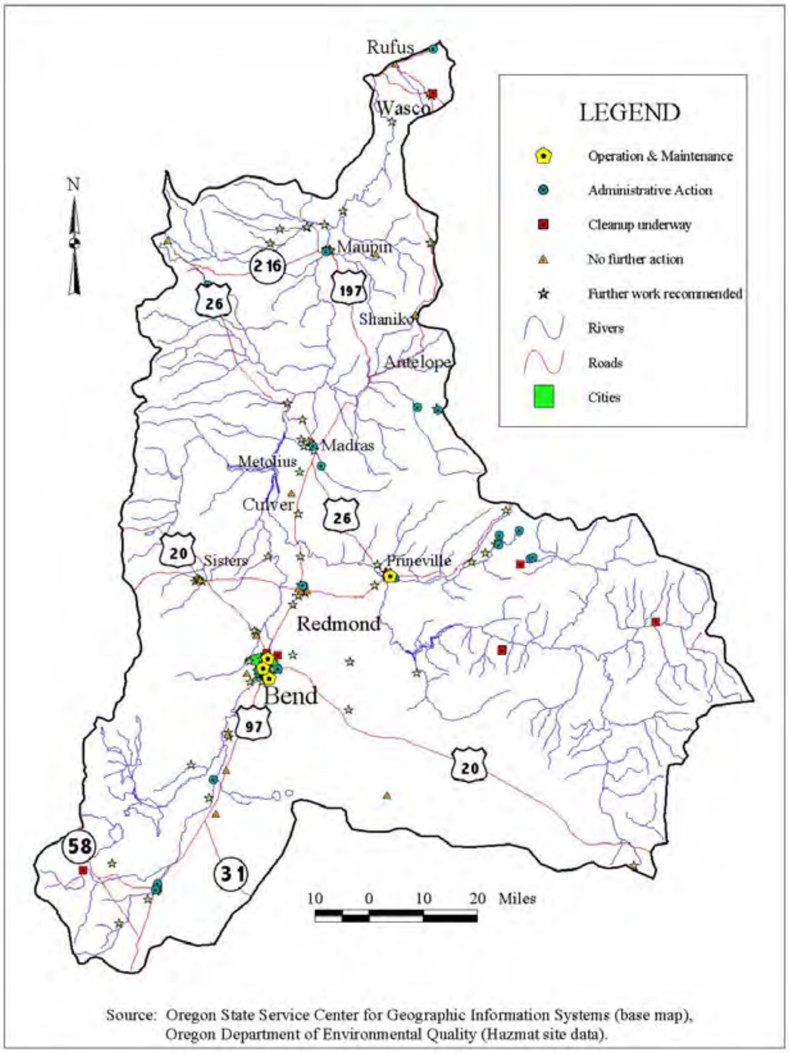
Figure 21. Confined Animal Feeding Operations in the Deschutes Basin.

Hazardous Substance Release Sites

The DEQ maintains a list of known hazardous substance release sites in the Environmental Cleanup Site Information (ECSI) database. Information on specific sites is available through on-line queries at http://www.deq.state.or.us/wmc/ECSI/ecsiquery.htm. As of February 2004, the database shows 200 sites in the Deschutes Basin. Figure 22 shows the site locations, and distinguishes them, according to the following five site types:

1. Administrative action (27 sites).
2. Operation and Maintenance (4 sites).
3. Cleanup underway (17 sites).
4. No further action (48 sites).
5. Further investigation or cleanup recommended (104 sites).

Some of the sites are very close to each other, causing some symbols to overlap and hide others.



Source: Oregon State Service Center for Geographic Information Systems (base map), Oregon Department of Environmental Quality (Hazmat site data).

Figure 22. Hazardous substance release sites in the Deschutes Basin.

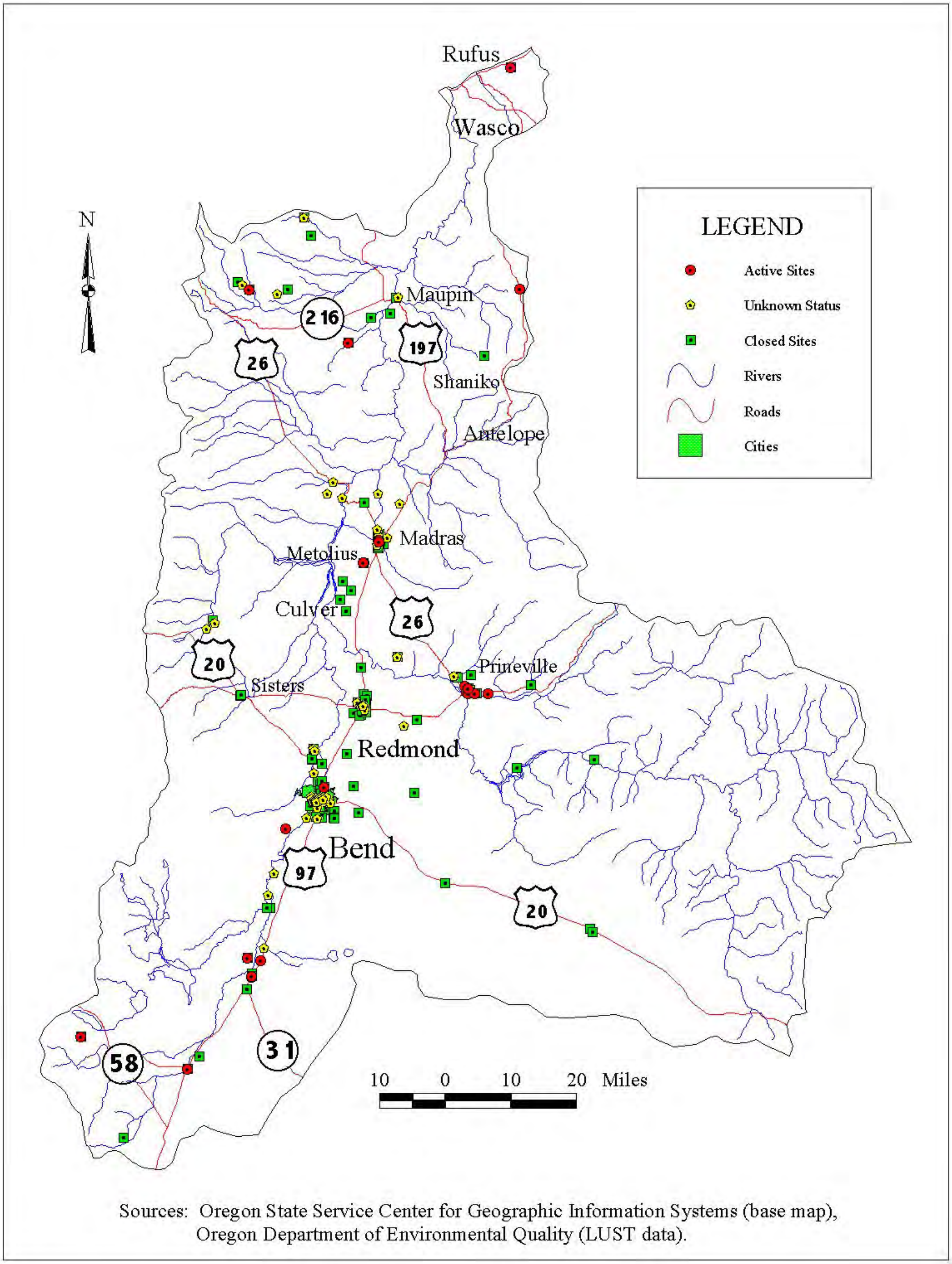
Underground Storage Tanks (USTs) and Leaking Underground Storage Tanks (LUSTs)

The DEQ Underground Storage Tank (UST) program regulates tanks storing petroleum or certain hazardous substances, and regulates tank release cleanups, including home heating oil tanks. The DEQ maintains the UST List for regulated underground storage tank facilities in Oregon. This list is available on-line at: http://www.deq.state.or.us/wmc/tank/ustfaclist.htm. The UST program also maintains a database of Leaking Underground Storage Tanks (LUST) where releases from tanks have been reported. This database is available on-line at: http://www.deq.state.or.us/wmc/tank/LustPublicLookup.asp.

The database, updated 10/23/01, has 350 records on file for LUST sites in the Deschutes Basin. Active sites account for 29 of these sites, 90 sites have an unknown status, and the remaining 231 sites are closed.

The Prineville area has seen major LUST activity in recent years due to a large concentration of LUSTS in downtown Prineville. The DEQ began an area-wide investigation of petroleum sources in 1997. The investigation showed several leaky underground storage tanks were contributing to shallow groundwater contamination and indoor air exceedances. Benzene was the primary constituent of concern. DEQ’s Orphan Site Program installed a soil vapor and groundwater remediation system in 1998. This system was designed to clean up and control the contamination from one of the major sources. The City of Prineville conducted additional removal actions, using an EPA Brownfields Cleanup grant in 2003 – 2004.

Figure 23 on the next page shows the site locations in the Deschutes Basin.



Sources: Oregon State Service Center for Geographic Information Systems (base map), Oregon Department of Environmental Quality (LUST data).

Figure 23. Locations of LUST sites in the Deschutes Basin.

Solid Waste Facilities

The DEQ has collected groundwater and leachate monitoring data at three landfills in the Deschutes Basin. These landfills are Crook County near Prineville, Knott Pit in Bend, and Southwest, between Sunriver and La Pine. Figure 9 shows the landfill locations. Crook County and Knott Pit landfills continue to accept waste through operating permits. Southwest landfill is now a transfer station. The DEQ Eastern Region office in The Dalles maintains information about the landfill status, monitoring results, and annual reports.

Crook County Landfill

Summary

Solid Waste Permit Number 74 regulates activities at the Crook County Landfill. The DEQ has collected and analyzed groundwater and leachate samples at the Crook County Landfill in 2001 and 2004.

The Crook County Landfill is located in volcaniclastic sediments overlying basalt flows of the Deschutes Formation. The aquifer underlying the landfill is confined, and depth to water is approximately 370 feet below ground surface.

Data from the DEQ's sampling are available in LASAR through the internet at: DEQ Lab LASAR, and can be retrieved using Crook County Landfill as the sampling event name.

Results

All three monitoring wells and the leachate site had detectable amounts of nitrates, barium, beryllium, chromium, and copper. However, all detections were below drinking water standards.

Knott Pit Landfill

Summary

Solid Waste Permit number 6 regulates activities at the Knott Pit landfill. The DEQ has collected and analyzed groundwater samples from the landfill's monitoring wells in 1995, 1999, 2002, and 2004.

The Knott Pit landfill is located within the down-thrown block of a normal fault. This graben, or basin, is filled with alluvial sediments that are mineralogically similar to the rocks of the Newberry Volcano, south of Bend and east of La Pine. Prior to use as a landfill, the location was the site of a gravel mine. The aquifer underlying the landfill is composed of Holocene age basalt and cinder interflow rocks. Depth to groundwater is approximately 670 feet below ground surface.

Data from DEQ's sampling events are available in LASAR through the internet at: DEQ Lab LASAR, and can be retrieved using Knott Landfill as the sampling event name.

Results

All five monitoring wells had generally low levels of nitrates, barium, chromium, cadmium, copper, and lead. One well had chromium and lead levels over the drinking water standards, and another well had chromium over the standard.

Southwest Landfill
Summary

Solid Waste Permit number 259 regulates activities at the Southwest landfill. The DEQ has collected and analyzed groundwater samples from the landfill numerous times since 1976.

Data from DEQ's sampling are available in LASAR through the internet at: DEQ Lab LASAR, and can be retrieved using Southwest Landfill as the sampling event name.

Results

The following constituents were detected in many of the wells over the years:

- antimony
- arsenic
- barium
- beryllium
- cadmium
- chromium
- copper
- lead
- mercury
- nitrates
- volatile organic compounds

One well had arsenic levels over the drinking water standard and another had antimony levels over the standard. All remaining detections were below drinking water standards.

The DEQ Solid Waste Program referred the site to the Cleanup Program to evaluate the nature and extent of groundwater contamination. The Cleanup Program issued a Record of Decision (ROD) in September 2000 which specified risk-based concentrations for groundwater constituent compliance levels. The DEQ plans to present the landfill's closure permit renewal for public review sometime in 2006. DEQ intends to incorporate the ROD's risk-based concentrations in the permit.

Box Canyon Landfill
Summary

The DEQ Lab has never conducted a split sampling event at the Box Canyon landfill. The Solid Waste Program referred the site to the Cleanup Program. Jefferson County is currently conducting an investigation to evaluate the nature and extent of groundwater contamination from the closed landfill. Constituents of concern include perchloroethylene, trichloroethene, and their degradation products.

CONCLUSIONS

The Deschutes Basin in central Oregon includes the headwaters of several rivers, and a vulnerable, sole-source groundwater aquifer. While much of the basin area is forest land, groundwater studies have focused on the areas with the highest population and commercial and agricultural activity. The La Pine aquifer is present in an area that has been the focus of growth and development in the basin. Other productive basin aquifers occur in shallow alluvial sediments. These aquifers are vulnerable to pollution from human activities.

Groundwater in the Deschutes Basin is a significant natural resource. There are 2,267 water rights for groundwater use in the basin. Over 370 public water systems, serving over 145,500 people in the basin, use groundwater, either exclusively, or in combination with surface water. Approximately 17,500 domestic water wells provide drinking water to residents without access to public water systems.

Groundwater quality studies in the Deschutes Basin have shown the presence of contaminants over established drinking water standards or Federal Action Levels. These contaminants include the following:

- nitrates
- bacteria
- lead
- thallium
- arsenic
- tetrachloroethylene
- dichloromethane
- 1,2-dichloroethane
- antimony
- chromium

Nitrate contamination is present in the Deschutes Basin, particularly in the Prineville and La Pine areas. In the Prineville area, 65% of the wells had nitrate levels at or above 2 mg/L, which indicates anthropogenic influences. Five of the wells (29%) had nitrate levels exceeding the drinking water standard of 10 mg/L. In the La Pine area, 49% of the wells had nitrate levels at or above 2 mg/L, and four of the wells (10%) had nitrate levels exceeding the drinking water standard. Public Water Systems and Real Estate Transaction testing programs have also reported nitrate detections.

The Oregon Department of Human Services, Drinking Water Program has conducted over 7,000 tests of water quality from private, domestic water wells in the Deschutes Basin. About 3% of these tests were positive for bacteria. Nitrate was detected in 2,905 of these tests, 47 (or less than one percent) of which exceeded the drinking water standard. The bacteria detections are likely due to poor well construction and maintenance activities, rather than a region-wide groundwater problem. Some of these bacteria detections may be due to sampling practices and sample handling procedures. Potential sources for the nitrate and bacteria contamination in areas within the Deschutes Basin include high densities of on-site septic systems in areas with permeable, sandy soils.

DEQ testing of 17 wells in the Prineville area detected one pesticide and one volatile organic compound (VOC), both of which were below drinking water standards. Similar testing of 39 wells in the La Pine area detected pesticides in five wells and VOCs in eight wells. One La

Pine well had a VOC over the drinking water standard. These detections probably represent localized spills or improper handling practices, rather than area-wide contamination problems.

RECOMMENDATIONS

Additional investigation and action are warranted in parts of the Deschutes Basin where nitrate, heavy metal, pesticide, and volatile organic compound (VOC) contamination occurs. Specific recommendations are as follows:

- In the Prineville area, conduct repeat sampling for nitrates, heavy metals, pesticides, and VOCs to determine trends in groundwater concentrations of these constituents.

- In the La Pine area, the DEQ should continue to work with Deschutes County to upgrade existing septic systems, and install new systems that have proven effective at reducing nitrate contamination. This collaborative work should establish a trending network to measure the septic management plan's effectiveness.

- In central Oregon, the DEQ, through its UIC program, should identify and control or eliminate contaminated stormwater discharge into drywells and other underground injection systems.

- Due to sensitive aquifers in the region, the groundwater resource in the Redmond area is vulnerable to contamination from anthropogenic activities. No assessment has been done here, so the DEQ should conduct an initial ambient groundwater sampling event in this area.

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APPENDIX 1

DATA TABLES

TABLE 1
Sampling Results from 1978 – 1979 DEQ La Pine Study

Site	Date	Nitrate	Bacteria
Carter	8/23/1978	6.38	Not App.
16387 4th St.	8/23/1978	8.32	Not App.
Al's Bakery	8/23/1978 9/20/1978 12/4/1978	19.0 19.98 N.A.	Not App. Not App. 2.2
Dr. Dunscombe, D.D.S.	8/23/1978 9/20/1978 12/4/1978	13.6 12.21 N.A.	Not App. Not App. 2.2
Pacific NW Bell Office	8/23/1978	0.57	Not App.
Campbell Well - CL&D	8/23/1978	0.61	Not App.
Kaplan Well - CL&D	8/23/1978	3.19	Not App.
Engburg Well - CL&D	8/23/1978	6.15	Not App.
Dwinnell Well - CL&D	8/23/1978	2.65	Not App.
Lohner Well - CL&D	8/23/1978	0.30	Not App.
Sugar Pine Cafe	9/20/1978 12/4/1978	6.22 N.A.	Not App. 2.2
LaPine Inn	12/4/1978	7.23	Not App.
Highlander Motel	12/4/1978	3.02	Not App.
Frank Williams	12/4/1978	9.09	Not App.
Joseph Burden	9/20/1978 12/4/1978	10.3 N.A.	Not App. 2.2
Claude River	9/20/1978 12/4/1978	12.35 N.A.	Not App. 2.2
Larson	12/4/1978	6.90	Not App.
Grade School	12/4/1978	5.67	Not App.
Donna Reed	12/4/1978	1.25	Not App.
Shields	9/20/1978 12/4/1978	0.21 2.34	Not App. Not App.
Well G (Roan Park)	12/4/1978	0.26	Not App.
Well H (Roan Park)	12/4/1978	0.03	Not App.
Westview Cafe	12/4/1978	0.75	Not App.
Howard Seed	12/4/1978	0.75	Not App.
LaPine Reality	12/4/1978	3.95	Not App.
Russell Industries	12/4/1978	6.97	Not App.
LaPine Bldg. Supply	12/4/1978	4.67	Not App.
Ardeth Reynolds	12/4/1978	13.50	Not App.

Lee Kennel	12/4/1978	0.25	Not App.
Midstate Electric	12/4/1978	0.87	Not App.
LaPine Hwy. Center (Well 1)	1/17/1979	9.23	Not App.
LaPine Hwy. Center (Well 2)	1/17/1979	12.30	Not App.
Aspen Alley (Hair Nook)	1/17/1979	1.30	Not App.
LaPine Texaco	1/17/1979	25.80	Not App.
First National Bank	1/17/1979	5.64	Not App.
LaPine Trailer Park	1/17/1979	4.25	Not App.
Rapp Clinic	1/17/1979	3.57	Not App.
Borden	1/17/1979	8.69	Not App.
Bob Nash	1/17/1979	2.11	Not App.
Alpine Foods	1/17/1979	3.82	Not App.
Highlander Trailer Park	1/17/1979	5.41	Not App.
Frontier Deli	1/17/1979	12.90	Not App.
Cascade Realty	1/17/1979	8.49	Not App.
Arthur Skidgel	1/17/1979	6.71	Not App.
Mike Lambert	1/17/1979	8.14	Not App.
Simpson	1/17/1979	6.90	Not App.
NOTES:			
Nitrate values in mg/L			
Bacteria values in number of colonies per 100 ml			
Not App. = Not Applicable			

Table 2.
Sampling Results from 1982 La Pine Study

Ponderosa Pines Well #2				
3/19/1979				
Constituent	**Concentration (mg/L)**			
Alkalinity as $CaCO_3$	48			
Arsenic	<0.005			
Calcium	4.7			
Chloride	5.5			
Coliform, Total (#/100 ml)	0			
Fluoride	0.72			
Hardness as $CaCO_3$	30			

Iron	0.08			
Manganese	0.002			
Magnesium	4.5			
Nitrate Nitrogen	0.28			
pH (S.U.)	7.6			
Silica	17			
Sodium	7.8			
Total Solids	166			
Volatile Solids	61			
Sulfate	2.5			
Turbidity (FTU)	2.0			
Color (Color Units)	5			
Sunriver Properties Well #2				
Constituent	**Mean (mg/L)**	**Max. (mg/L)**	**Min. (mg/L)**	**# of samples**
Turbidity (JTU)	1	1	1	3
Total Solids	99	106	93	3
Volatile Solids	27	30	24	3
Carbon Dioxide	1.8	3	1	3
pH (S.U.)	7.8	8	7.7	3
Alkalinity as $CaCO_3$	47	47	47	3
Hardness as $CaCO_3$	29.2	29.5	29	3
Calcium	5.3	5.8	4.4	3
Magnesium	4.0	4.6	3.6	3
Iron	-	<0.05		3
Manganese	-	0.05	<0.05	3
Arsenic	-	0.006	<0.005	3
Conductance (uMhos/cm)	121	126	114	3
Chloride	3.2	4.8	1.6	3
Sodium	11.1	12.4	9	3
Potassium	1.6	2.0	1.0	3
Fluoride	0.2	0.42	0.06	3
Ortho Phosphate	0.57	0.73	0.45	3
Sulfate	2.6	3.7	0.6	3
Silica	31.2	32.5	29	3
Aluminum	-	0.03	<0.01	3
Ammonia Nitrogen	-	0.10	<0.01	3

Nitrite Nitrogen	-	0.03	<0.01	3
Nitrate Nitrogen	0.05	0.08	0.03	3
Color (color units)	1.7	5	0	3
La Pine School				
10/13/1978				
Constituent	**Concentration (mg/L)**			
Alkalinity as $CaCO_3$	992			
Arsenic	0.009			
Calcium	172			
Chloride	5.5			
Coliform, Total (#/100 mg/L)	0			
Fluoride	0.56			
Hardness as $CaCO_3$	8.19			
Iron	3.9			
Manganese	0.29			
Magnesium	95			
Nitrate Nitrogen	0.13			
pH (S.U.)	7.8			
Silica	18			
Sodium	170			
Total Solids	1488			
Volatile Solids	640			
Sulfate	31			
Turbidity (FTU)	68			
Color (Color Units)	50			
Glenwood Land & Water Company				
8/2/1978				
Constituent	**Concentration (mg/L)***			
Alkalinity as $CaCO_3$	596			
Arsenic	<0.005			
Calcium	45			
Conductance (uMhos/cm)	1074			
Fluoride	0.2			
Hardness as $CaCO_3$	329			

Iron	5.3			
Manganese	0.18			
Magnesium	40			
Nitrate Nitrogen	0.04			
Ammonia Nitrogen	31.9			
pH (S.U.)	7.4			
Sodium	92			
Total Solids	571			
Sulfate	2.0			
Turbidity (FTU)	46			
Color (Color Units)	40			
Potassium	5.4			
Phosphate - as P	0.137			
* Unfiltered				
Glenwood Land & Water Company				
8/2/1978				
Constituent	**Concentration (mg/L)***			
Alkalinity as $CaCO_3$	644			
Arsenic	<0.005			
Calcium	43.6			
Chloride	18			
Conductance (uMhos/cm)	1127			
Fluoride	0.3			
Hardness as $CaCO_3$	353			
Iron	5.9			
Manganese	0.19			
Magnesium	40			
Nitrate Nitrogen	0.03			
Ammonia Nitrogen	31.9			
pH (S.U.)	7.7			
Sodium	101			
Total Solids	630			
Sulfate	1.7			
Turbidity (FTU)	12			
Color (Color Units)	30			
Potassium	5.5			

Phosphate - as P	0.961			
* After Fiber Filter				
Glenwood Land & Water Company				
8/2/1978				
Constituent	**Concentration (mg/L)[*]**			
Alkalinity (Bicarbonate) as $CaCO_3$	608			
Arsenic	<0.005			
Calcium	43.6			
Chloride	18.7			
Conductance (uMhos/cm)	1100			
Fluoride	0.2			
Hardness as $CaCO_3$	330			
Iron	3.5			
Manganese	0.18			
Magnesium	40			
Nitrate Nitrogen	0.14			
Ammonia Nitrogen	32.7			
pH (S.U.)	7.6			
Sodium	104			
Total Solids	615			
Sulfate	1.7			
Turbidity (FTU)	8			
Color (Color Units)	30			
Potassium	5.5			
Phosphate - as P	0.603			
* After Charcoal Filter				
Oregon Water Wonderland Unit 1				
11/14/1969				
Constituent	**Concentration (mg/L)[*]**			
Alkalinity (Bicarbonate) as $CaCO_3$	143			
Arsenic	0.009			
Calcium	8.3			
Chloride	2.5			

Fluoride	0.29			
Hardness as $CaCO_3$	60			
Iron	2.4			
Manganese	0.16			
Magnesium	9.6			
Nitrate Nitrogen	0.38			
Silica	13.1			
Sodium	40.0			
Total Solids	170			
Sulfate	2.2			
Aluminum	1.0			
Potassium	2.8			
* water from 6 wells, 65' to 686' deep				
Ponderosa Pines Well #1				
4/16/1971				
Constituent	**Concentration (mg/L)**			
Alkalinity (Carbonate) as $CaCO_3$	86			
Arsenic	0.01			
Calcium	26			
Chloride	4.2			
Fluoride	0.17			
Hardness as $CaCO_3$	70			
Iron	0.2			
Manganese	0.01			
Magnesium	1.0			
Nitrate Nitrogen	0.45			
Nitrite Nitrogen	0.03			
pH (S.U.)	10.0			
Silica	45			
Sodium	8.1			
Total Solids	134			
Volatile Solids	36			
Sulfate	1.6			
Potassium	2.0			
Aluminum	0.04			

Stage Stop				
12/26/1973				
Constituent	**Concentration (mg/L)**			
Alkalinity as $CaCO_3$	58.8			
Arsenic	-			
Calcium	9.0			
Chloride	3.7			
Fluoride	0.24			
Hardness as $CaCO_3$	55.0			
Iron	0.40			
Manganese	<0.01			
Magnesium	6.0			
Nitrate Nitrogen	0.70			
pH (S.U.)	6.7			
Silica	43.0			
Sodium	9.0			
Total Solids	106.0			
Volatile Solids	68.0			
Sulfate	<0.01			
Turbidity (FTU)	8.0			
Potassium	0.70			

Table 3.
Sampling Results from Shields Disposal Site

Shields Septic Disposal Site (Well 1)				
Constituent (mg/L, unless shown)	**Mean**	**Max.**	**Min.**	**# of samples**
Ammonia Nitrogen	0.12	0.27	0.02	3
Nitrate Nitrogen	0.59	1.5	0.10	3
Chloride	2.2	3.0	1.7	3
Conductance (uMhos/cm)	-	234	217	2
Total coliform (#/100 ml)	-	2200	<100	3
Fecal coliform (#/100 ml)	-	<10	-	3
Yeserinia enterocolitica - present				
Entero agglomerulans - present				

Shields Septic Disposal Site (Well 2)				
Constituent (mg/L, unless shown)	**Mean**	**Max.**	**Min.**	**# of samples**
Ammonia Nitrogen	-	0.12	0.08	2
Nitrate Nitrogen	-	0.17	0.16	2
Chloride	-	4.2	2.0	2
Conductance (uMhos/cm)	-	207	160	2
Total coliform (#/100 ml)	-	140,000	<100	2
Fecal coliform (#/100 ml)	-	<100	<10	2
Yeserinia enterocolitica - absent				
Entero agglomerulans - present				
Shields Septic Disposal Site (Well 3)				
Constituent (mg/L, unless shown)	**Mean**	**Max.**	**Min.**	**# of samples**
Ammonia Nitrogen	-	0.24	0.16	2
Nitrate Nitrogen	-	4.2	0.09	2
Chloride	-	6.0	5.4	2
Conductance (uMhos/cm)	-	246	-	1
Total coliform (#/100 ml)	-	140,000	<100	2
Fecal coliform (#/100 ml)	-	<100	<10	2
Yeserinia enterocolitica - present				
Entero agglomerulans - present				
Shields Septic Disposal Site (Well 4)				
Constituent (mg/L, unless shown)	**Mean**	**Max.**	**Min.**	**# of samples**
Ammonia Nitrogen	0.13	0.25	0.04	3
Nitrate Nitrogen	1.12	3.2	0.06	3
Chloride	6.0	7.0	5.0	3
Conductance (uMhos/cm)	-	218	192	2
Total coliform (#/100 ml)	-	88,000	<100	3
Fecal coliform (#/100 ml)	-	<100	<10	3
Yeserinia enterocolitica - absent				
Entero agglomerulans - present				

Analyte (1)	Well I.D. (LASAR No.)												
	14687	14688	14689	14690 (3)	14691	14692	14693	14694	14695	14696	14697	14698	14699
Sample Date	6/29/1993	6/29/1993	6/29/1993	6/29/1993	6/29/1993	6/29/1993	6/30/1993	6/30/1993	6/30/1993	6/30/1993	6/30/1993	6/30/1993	6/30/1993
Physical/Chemical Properties													
Alkalinity	304	272	293	298	372	572	250	262	237	325	218	221	333
COD	<5	<5	<5	<5	8	10	<5	<5	<5	<5	5	<5	<5
Conductivity (umhos/cm)	640	643	590	643	794	1386	595	800	562	774	614	484	643
Hardness	230	260	160	250	290	250	220	310	210	340	140	190	240
pH (S.U.)	7.8	7.4	8	7.6	7.9	7.8	7.8	7.7	7.7	8.0	8.1	7.9	7.6
Temperature	12.0	14.0	13.0	12.5	13.0	13.5	13.3	14.0	14.3	12.5	13.0	13.0	14.0
Total Dissolved Solids	430	420	390	440	500	930	390	540	330	520	420	310	420
Total Organic Carbon	2	1	2	2	4	6	2	2	1	2	2	1	2
Turbidity (NTU)	1	<1	2	3	1	<1	<1	<1	<1	<1	3	8	2
Common Ions													
Calcium, Total	56	64	36	61	64	55	60	78	49	77	33	43	54
Chloride	12	19	10.0	26	19	59	14	16	5.9	9.3	14	13	10
Fluoride	0.3	0.3	0.4	0.3	0.4	0.2	0.6	0.5	0.3	0.4	0.6	0.2	0.2
Magnesium, Total	23	24	16	24	31	27	17	27	22	36	14	21	26
Manganese, Total	<0.01	<0.01	0.18	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	0.63	1.3
Potassium, Total	2.8	2.4	3.6	2.7	4.2	8.1	0.9	3.6	3.4	3.2	3.0	5.1	5.5
Sodium, Total	66	48	92	71	86	250	58.0	68	40	56	92	34	65
Sulfate	40.0	52	33	49	38	70.0	35	65	27	39	39	29	25
Metals													
Aluminum, Total	<0.1	<0.1	<0.1	<0.1	<0.1	5.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic, Total	<0.005	<0.005	<0.005	<0.005	<0.005	0.014	0.009	<0.005	<0.005	<0.005	0.010	<0.005	<0.005
Barium, Total	0.03	0.03	0.03	<0.03	0.04	0.04	<0.03	0.03	<0.03	0.05	<0.03	0.04	0.03
Beryllium, Total	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	<0.03	0.09	0.04	0.04	0.07	0.45	<0.03	<0.03	<0.03	<0.03	0.08	<0.03	<0.03
Cadmium, Total	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium, Total	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Cobalt, Total	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Copper, Total	<0.02	<0.02	<0.02	<0.02	0.09	<0.02	<0.02	0.04	0.04	<0.02	0.08	<0.02	<0.02
Iron, Total	0.06	<0.04	0.45	0.29	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.38	1.6	0.17
Lanthanum, Total	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lithium, Total	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Molybdenum, Total	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel, Total	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Selenium, Total	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Silicon as Silica (SiO2)	49	47	47	45	51	48	53	51	48	50	50	55	49
Silver, Total	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium, Total	<0.03	<0.03	<0.03	<0.03	0.09	0.13	<0.03	0.03	<0.03	0.04	0.10	<0.03	<0.03
Zinc, Total	<0.02	0.03	0.06	<0.02	0.03	0.04	<0.02	0.08	<0.02	<0.02	1.3	<0.02	1.2
Nutrients													
Ammonia as N	<0.02	0.02	0.26	0.02	0.03	<0.02	0.03	0.02	<0.02	<0.02	0.02	1.41	0.05
Nitrate & Nitrite as N	4.1	3.7	0.19	0.35	4.2	22	3.6	23	3.9	20	15	0.03	1.6
Phosphate, Total	0.14	0.17	0.15	0.10	0.11	1.8	0.13	0.09	0.17	0.12	0.27	0.25	0.28
Total Kjeldahl Nitrogen	0.2	0.2	0.3	<0.2	0.4	0.6	0.2	0.2	<0.2	0.3	0.3	1.4	0.2
Pesticides													
Aldicarb	<0.0036	<0.0036	<0.0036	0.0001	<0.0036	<0.0036	<0.0036	<0.0036	<0.0036	<0.0036	<0.0036	<0.0036	<0.0036
Carbofuran	<0.0074	<0.0074	<0.0074	<0.0074	<0.0074	<0.0074	<0.0074	<0.0074	<0.0074	<0.0074	<0.0074	<0.0074	<0.0074
Oxamyl	<0.0064	<0.0064	<0.0064	<0.0064	<0.0064	<0.0064	<0.0064	<0.0064	<0.0064	<0.0064	<0.0064	<0.0064	<0.0064
Atrazine	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bromacil	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015
Carboxin	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Metribuzin	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Simazine	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Diuron	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004
2,4-D	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Dicamba	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Dinoseb	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Volatile Organic Compounds													
EPA 8260 VOCs	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	Toluene 0.0035	N.D.	N.D.	N.D.
NOTES:													
(1) Values are in mg/L (parts per million).													
(2) N.D. = None Detected.													
(3) Results from duplicate samples (i.e., two samples from one well) were averaged into one number for inclusion in this table.													

Table 4. Sampling Results from 1993 DEQ Prineville Study

Table 5. Sampling Results from 1993 La Pine Study

Analyte (1)					**Well I.D. (LASAR No.)**				
LASAR #	14675	14521	14522	14523	14524	14525	14526	14527	14528
Sample Date	5/24/1993	5/24/1993	5/24/1993	5/24/1993	5/25/1993	5/25/1993	5/25/1993	5/25/1993	5/25/1993
Physical/Chemical Properties									
Alkalinity	120	74	43	42	39	57	51	51	37
COD	5	<5	<5	<5	<5	7	5	<5	<5
Conductivity (umhos/cm)	324	322	153	85	214	254	261	121	176
Hardness	140	120	54	31	74	79	85	44	49
pH (S.U.)	7.2	6.8	7.4	7.5	7.0	7.1	6.7	7.4	6.5
Temperature	11.0	8.5	9.0	9.0	12.0	12.0	11.0	12.5	12.0
Total Dissolved Solids	250	280	150	100	180	210	220	120	160
Total Organic Carbon	2	1	<1	<1	1	2	2	<1	1
Turbidity (NTU)	4	<1	<1	<1	<1	<1	<1	<1	<1
Common Ions									
Calcium, Total	24	20	9.3	5.0	14	15	16	7.8	9.3
Chloride	36	27	9.2	1.6	13	27	21	2.9	3.5
Magnesium, Total	20	16	7.6	4.4	9.4	10	11	6.0	6.2
Manganese, Total	0.86	<0.01	0.01	<0.01	<0.01	0.02	<0.01	0.02	<0.01
Potassium, Total	1.9	4.8	1.4	1.9	4.1	4.5	5.0	2.7	6.0
Sodium, Total	15	18	10	7.8	12	16	15	8.3	11
Sulfate	7.3	7.7	5.2	2.5	15.0	6.5	16	3.5	8.6
Metals									
Aluminum, Total	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic, Total	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Barium, Total	<0.03	<0.03	0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Beryllium, Total	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	<0.03	<0.03	<0.03	<0.03	<0.03	0.04	<0.03	<0.03	<0.03
Cadmium, Total	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium, Total	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Cobalt, Total	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Copper, Total	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.17	<0.02	<0.02
Iron, Total	3.5	<0.04	<0.04	0.05	0.04	<0.04	<0.04	0.07	0.08
Lanthanum, Total	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead, Total	<0.005	0.009	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Lithium, Total	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, Total	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Molybdenum, Total	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel, Total	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Selenium, Total	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Silicon as Silica (SiO2)	49	54	56	54	58	62	66	60	60
Silver, Total	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium, Total	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Zinc, Total	<0.02	<0.02	0.09	<0.02	0.07	<0.02	0.03	<0.02	<0.02
Nutrients									
Ammonia as N	0.02	<0.02	<0.02	<0.02	0.02	0.02	0.06	0.02	0.02
Nitrate & Nitrite as N	<0.02	11	4.4	0.78	8.0	4.9	6.5	1.6	1.6
Phosphate, Total	0.21	0.09	0.25	0.19	0.08	0.14	0.12	0.23	0.23
Total Kjeldahl Nitrogen	<0.2	0.2	<0.2	<0.2	<0.2	0.5	1.4	<0.2	<0.2
Pesticides									
Atrazine	<0.0001	<0.0001	<0.0001	<0.0001	0.0004	<0.0001	<0.0001	<0.0001	<0.0001
Bromacil	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022
Diuron	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Diclobenil	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006
2,4-D	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Dicamba	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Picloram	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Volatile Organic Compounds									
EPA 8260 VOCs	1,2-Dichloroethane 0.019, 1,2-Dimethlybenzene 0.038, 1,2,4-Trimethylbenzene 0.008	1,4/1,3-Dimethylbenzene 0.0006	N.D.	N.D.	1,1,1-Trichloroethane 0.001	Benzene 0.090, Ethyl Benzene 0.0013, 1,4/1,3-Dimethylbenzene 0.0017, 1,2-Dimethlybenzene 0.0034, 1,2,4-Trimethlybenzene 0.0018	N.D.	N.D.	N.D.
NOTES:									
(1) Values are in mg/L (parts per million).									
(2) N.D. = None Detected.									
(3) Results from duplicate samples (i.e., two samples from one well) were averaged into one number for inclusion in this table.									

14570	14580	14591	14602	14613 (3)	14624	14633	14642	14524	14652	14521	14522	14523 (3)	14658	14659
5/25/1993	5/26/1993	5/26/1993	5/26/1993	5/26/1993	5/26/1993	5/26/1993	5/26/1993	7/12/1993	7/12/1993	7/12/1993	7/12/1993	7/12/1993	7/13/1993	7/13/1993
89	61	70	34	43	34	103	74	38	38	75	43	42	27	49
<5	<5	<5	<5	<5	<5	5	<5	<5	<5	5	3	<5	8	6
371	212	270	97	111	195	344	237	215	236	315	126	89	321	92
120	68	94	31	37	58	130	87	74	79	120	45	31	84	33
6.9	6.7	6.8	7.3	7.4	6.8	7.5	7.2	7.0	7.0	6.8	7.3	7.3	6.7	7.5
10.5	12.0	9.0	9.5	10.0	9.0	9.0	10.0	10.0	10.0	7.5	8.5	9.0	8.5	8.5
260	160	200	110	120	170	250	180	200	210	260	110	99	250	91
2	1	1	<1	<1	1	1	<1	1	1	1	<1	<1	2	<1
<1	<1	<1	<1	<1	<1	20	<1	<1	<1	<1	<1	<1	<1	1
22	13	18	5.6	6.6	11	21	15	14	15	21	7.7	5.2	14	5.3
18	11	14	3.3	5.0	9.5	46	12	14	16	29	5.5	1.5	33	1.0
15	8.6	12	4.2	5.0	7.3	20	12	9.6	10	17	6.3	4.6	12	4.8
<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.76	0.04	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.20
6.0	4.3	4.8	2.1	2.1	4.1	1.4	1.4	4.1	4.6	4.9	1.5	1.6	5.3	1.8
26	11	14	6.9	7.6	14	14	14.0	12	14	18	9	7.8	27	6.9
22	11	16	4.6	5.5	22	6.2	6.3	16	19	9.4	4.1	2.8	13	2.7
<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.09	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
<0.04	<0.04	<0.04	0.06	<0.04	<0.04	5.1	0.06	<0.04	0.04	<0.04	<0.04	<0.04	<0.04	1.0
<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
58	60	59	55	52	61	48	60	56	56	54	46	51	60	44
<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.15	<0.02	<0.02	0.38	0.03	0.09	<0.02	0.02	<0.02
0.03	<0.02	<0.02	0.02	0.03	<0.02	0.25	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.36
14	3.8	6.2	1.4	0.91	4.8	0.0	6.8	8.7	8.3	10	2.8	0.80	16	0.03
0.11	0.16	0.12	0.23	0.26	0.37	0.34	0.10	0.09	0.09	0.09	0.26	0.19	0.07	0.38
0.2	<0.2	0.2	<0.2	0.2	0.2	0.3	<0.2	<0.2	0.2	0.2	0.2	<0.2	0.2	0.4
<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00019	0.0002	0.00011	<0.0001	<0.0001	0.00108	<0.0001
<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015
<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004
<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007
<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0002	0.0007	<0.0001	<0.0001	<0.0001	0.0035	<0.0001
<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	1,4/1,3-Dimethylbenzene 0.008	1,1,1-Trichloroethane 0.0009	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

14664	14665 (3)	14666	14667	14668	14675	14633	14669	14670	14671	14673	14672 (3)	14674
7/13/1993	7/13/1993	7/13/1993	7/13/1993	7/13/1993	7/14/1993	7/14/1993	7/14/1993	7/14/1993	7/14/1993	7/14/1993	7/14/1993	7/14/1993
42	39	41	41	37	116	143	35	59	70	83	53	61
<5	<5	<5	<5	<5	8	11	<5	<5	19	8	10	<5
113	83	82	90	81	331	547	104	119	128	159	108	123
37	30	30	33	22	150	240	36	45	70	40	43	46
7.3	7.4	7.1	7.4	8.5	7.4	7.4	7.1	7.5	7.0	7.4	7.3	7.5
8.5	8.5	8.0	8.0	8.5	11.0	11.0	7.5	9.0	8.0	8.0	8.0	8.5
120	93	89	100	72	220	300	110	110	160	110	100	100
<1	<1	<1	<1	<1	1	2	<1	<1	6	2	4	1
<1	<1	1	1	1	1	31	<1	1	<1	6	<1	<1
7.3	5.6	5.3	6.6	4.3	23	37	7.0	7.0	9.6	8.3	7.3	6.7
3.4	1.1	1.0	0.7	1.4	34	96	3.7	1.1	11	1.6	1.7	1.1
4.6	3.9	4.0	4.0	2.8	22	35	4.5	6.7	11	4.8	5.0	7.1
<0.01	<0.01	<0.01	<0.01	<0.01	0.71	1.3	<0.01	0.14	<0.01	0.36	<0.01	<0.01
2.9	2.4	2.4	2.5	1.1	1.7	1.7	2.7	1.6	3.1	1.5	2.2	1.7
8.2	6.6	6.8	6.4	9.7	15	18	7.3	9.5	16	16	8.7	10
3.2	1.8	0.8	0.6	1.0	8.2	9.9	4.2	4.7	5.7	4.7	1.5	1.4
<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
<0.02	<0.02	0.02	<0.02	<0.02	0.03	0.03	0.03	0.03	<0.02	<0.02	<0.02	<0.02
<0.04	<0.04	0.10	0.07	0.11	0.62	6.2	0.04	0.81	<0.04	2.9	2.9	0.09
<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
50	48	52	48	26	50	47	51	48	50	44	44	45
<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
0.03	<0.02	0.06	0.03	<0.02	<0.02	0.16	<0.02	<0.02	<0.02	0.03	<0.02	<0.02
0.02	0.02	0.02	0.02	0.06	0.19	0.24	0.02	0.09	0.02	3.1	0.09	<0.02
1.8	0.68	0.15	1.2	0.59	0.02	0.04	2.2	<0.02	2.6	<0.02	0.14	0.36
0.20	0.23	0.20	0.11	0.22	0.04	0.21	0.16	0.46	0.12	1.1	0.22	0.27
<0.2	<0.2	<0.2	<0.2	<0.2	0.2	0.3	<0.2	<0.2	0.3	2.9	0.2	<0.2
0.00024	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015
<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004
<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007
<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
N.D.	N.D.	N.D.	N.D.	N.D.	Toluene 0.038, Ethyl Benzene 0.048, 1,2-Dimethlybenzene 0.036, 1,2,4-Trimethylbenzene 0.016	1,2-Dichloroethane 0.0318, Ethyl Benzene 0.0046, 1,4/1,3-Dimethylbenzene 0.01025	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Table 6. Sampling Results from 1994-1995 Study

Well I.D.	Date	Conductivity (umhos/cm)	Depth to Water (ft)	Temp. (^oC)	Nitrate as N (mg/L)
14718	9/20/1994	324	N.A.	8.0	1.3
14719	9/20/1994	85	42.54	7.0	<0.1
14720	9/20/1994	83	34.35	7.8	1.0
14627	9/20/1994	77	44.39	7.9	1.9
14721	9/21/1994	342	13.23	11.6	5.1
14722	9/21/1994	351	11.95	15.0	4.6
14723	9/21/1994	169	N.A.	10.5	4.6
14724	9/21/1994	207	10.39	12.5	3.2
14724	9/27/1994	209	10.42	15.0	3.5
14725	9/21/1994	182	7.49	8.5	1.1
14716	9/19/1994	117	41.62	8.0	0.3
14717	9/19/1994	94	31.18	8.3	<0.1
14728	9/22/1994	96	37.13	9.9	1.8
14729	9/22/1994	85	38.42	10.0	1.0
14730	9/22/1994	66	49.67	11.9	1.4
14731	9/22/1994	103	26.04	12.5	1.7
14530	9/22/1994	129	25.97	12.2	2.7
14531	9/22/1994	97	12.72	10.8	1.4
14532	9/22/1994	96	17.92	12.2	0.7
N.A.	9/22/1994	N.A.	15.61	N.A.	N.A.
N.A.	9/22/1994	143	12.68	8.0	1.0
N.A.	9/22/1994	608	N.A.	7.0	1.1
N.A.	9/22/1994	177	14.54	8.0	1.2
N.A.	9/22/1994	244	52.03	9.0	0.9
N.A.	9/22/1994	174	14.79	7.0	0.8
N.A.	9/22/1994	231	17.11	8.0	1.0
N.A.	9/22/1994	497	3.10	8.0	0.70
N.A.	9/22/1994	541	6.80	7.5	1.3
N.A.	9/22/1994	122	5.12	8.0	1.5
N.A.	9/21/1994	527	19.46	9.0	0.9
N.A.	9/21/1994	452	30.50	9.0	0.7
N.A.	9/21/1994	124	23.50	9.0	2.0
N.A.	9/21/1994	135	41.07	8.0	0.7
N.A.	9/21/1994	292	9.63	8.0	1.4
N.A.	9/21/1994	186	13.72	7.0	1.2
N.A.	9/21/1994	158	14.20	7.5	0.9
N.A.	9/21/1994	103	13.56	8.0	1.6
N.A.	9/19/1994	96	194.78	9	0.7
N.A.	9/20/1994	130	105.65	10.0	0.5
N.A.	9/20/1994	106	N.A.	9.5	0.3
N.A.	9/20/1994	N.A.	9.00	N.A.	N.A.
N.A.	9/20/1994	120	N.A.	9.5	1.1
N.A.	9/20/1994	104	1.57	8.0	0.0
14716	9/25/1995	118	N.A.	7.1	0.03
14719	9/25/1995	89	N.A.	7.1	0.16
14717	9/25/1995	93	N.A.	7.1	<0.02
14718	9/25/1995	88	N.A.	7.3	0.29
14603	9/29/1994	87	119.73	7	1.1
14603	9/26/1995	96	N.A.	7.9	0.11
23440	9/26/1995	95	N.A.	8.1	0.13
14604	9/29/1994	232	8.14	6.0	1.1
14604	9/26/1995	252	N.A.	7.6	<0.02
23443	9/26/1995	108	N.A.	8.6	0.06
14596	9/30/1994	96	28.03	8.0	1.0
14596	9/26/1995	101	N.A.	8.2	0.06
14598	9/30/1994	200	19.19	9.0	3.8
14598	9/26/1995	230	N.A.	8.8	4.4
14605	9/29/1994	145	16.04	7.0	0.9
14605	9/27/1995	154	6.68	7.5	<0.02

14595	9/30/1994	99	11.07	7.0	0.6
14595	9/27/1995	110	11.49	7.6	<0.02
14597	9/30/1994	96	16.56	7.0	0.5
14597	9/27/1995	106	N.A.	7.6	<0.02
10000	9/27/1995	113	1.95	7.9	<0.02
14546	9/27/1995	189	16.73	7.7	<0.02
14547	9/27/1995	253	17.06	8.1	<0.02
14550	9/27/1995	574	6.70	7.8	<0.02
14549	9/27/1995	550	2.72	7.3	<0.02
14551	9/27/1995	115	4.79	11.1	0.07
14726	9/25/1995	132	N.A.	9.0	0.06
14533	9/25/1995	497	N.A.	17.1	8.6
14615	9/27/1994	90	4.24	8.0	1.2
14615	9/25/1995	97	N.A.	8.6	0.06
14727	9/25/1995	164	N.A.	8.0	<0.02
14608	9/28/1994	96	1.42	8.0	1.1
14608	9/25/1995	101	N.A.	8.3	0.06
14609	9/28/1994	95	7.60	8.0	1.1
14609	9/25/1995	110	N.A.	7.1	<0.02
14610	9/28/1994	107	11.56	8.0	1.5
14611	9/28/1994	252	8.15	8.0	0.4
14610	9/25/1995	115	N.A.	8.4	0.07
14534	9/25/1995	427	N.A.	8.3	<0.02
14535	9/25/1995	601	N.A.	12.4	2.6
14614	9/27/1994	391	22.45	7.5	1.5
14614	9/25/1995	470	N.A.	7.6	<0.02
14606	9/28/1994	92	12.75	7.0	1.2
14606	9/25/1995	108	N.A.	13.2	<0.02
14607	9/28/1994	N.A.	11.18	N.A.	N.A.
14607	9/25/1995	105	N.A.	8.7	0.04
14579	9/29/194	81	80.06	11.2	0.9
14581	9/29/1994	54	23.84	10.9	0.3
14579	9/25/1995	87	N.A.	8.6	0.08
14578	9/29/1994	84	N.A.	13.2	0.1
14578	9/25/1995	86	N.A.	8.3	0.08
14568	9/28/1994	108	39.20	10.9	1.3
14568	9/25/1995	124	N.A.	22.0	<0.02
14625	9/29/1994	412	14.77	7.0	0.6
14625	9/27/1995	481	15.21	9.1	<0.02
14620	9/26/1994	410	25.01	7.5	1.4
14620	9/27/1995	445	15.29	7.7	<0.02
14621	9/29/1994	245	14.21	8.0	1.0
14621	9/27/1995	274	14.68	7.6	<0.02
14622	9/29/1994	139	4.97	8.0	0.0
14622	9/27/1995	151	4.61	9.6	0.07
14623	9/29/1994	74	17.11	8.0	0.7
14623	9/28/1995	77	19.87	7.5	0.19
14618	9/27/1994	1256	26.24	7.5	N.A.
14618	9/28/1995	1300	24.00	7.9	N.A.
14617	9/27/1994	330	12.71	7.5	1.9
14617	9/28/1995	362	12.57	7.5	<0.02
14601	9/29/1994	231	9.12	8.0	0.7
14601	9/28/1995	277	9.13	7.5	<0.02
14612	9/28/1994	85	35.81	7.0	0.6
14612	9/28/1995	90	36.03	7.2	0.30
14542	9/28/1995	160	14.90	7.9	<0.02
14543	9/28/1995	156	11.35	7.9	<0.02
14536	9/28/1995	122	24.35	8.6	<0.02
14544	9/28/1995	678	23.08	7.5	0.02
14545	9/28/1995	191	13.65	7.8	<0.02
14537	9/28/1995	145	41.44	8.2	0.30
14538	9/28/1995	317	10.17	7.7	<0.02
14540	9/28/1995	190	14.32	7.3	0.54

14541	9/28/1995	173	14.22	7.5	0.59
14619	9/27/1994	404	66.45	10.0	1.5
14619	9/27/1995	400	62.10	12.0	0.81
14599	9/29/1994	88	24.86	7.0	0.4
14599	9/27/1995	95	26.12	8.0	0.16
14600	9/29/1994	85	48.41	6.0	1.1
14600	9/27/1995	93	49.95	6.9	0.10
14730	9/27/1995	74	56.66	7.6	0.20
14731	9/27/1995	127	28.02	8.1	2.8
14627	9/27/1995	88	46.51	7.6	0.13
14729	9/27/1995	92	35.18	7.6	<0.02
14530	9/27/1995	138	28.19	7.9	3.0
14720	9/27/1995	86	38.21	7.4	0.13
14728	9/27/1995	100	39.19	7.7	0.06
14585	9/30/1994	95	30.55	11.9	1.3
14585	9/29/1995	106	30.46	8.0	0.15
14586	9/30/1994	132	21.83	12.0	1.9
14586	9/27/1995	138	23.24	8.0	2.8
14567	9/28/1994	132	17.40	10.1	2.3
14567	9/27/1995	143	18.61	8.2	3.0
14532	9/29/1995	113	19.11	8.6	<0.02
14630	9/29/1995	147	18.72	8.9	1.9
14582	9/29/1994	222	24.53	10.0	6.0
14582	9/27/1995	223	25.30	8.2	5.9
14566	9/28/1994	88	27.95	10.9	2.4
14566	9/27/1995	93	22.72	8.4	0.03
14572	9/28/1994	114	15.55	10.2	1.6
14572	9/29/1995	121	16.38	7.7	0.11
14592	9/30/1994	123	23.45	13.0	2.9
14592	9/28/1995	167	N.A.	8.8	7.4
14593	9/30/1994	108	27.81	11.5	3.3
14593	9/29/1995	109	27.51	8.3	2.5
14576	9/29/1994	95	22.73	10.9	0.9
14577	9/29/1994	100	14.88	10.1	1.1
14576	9/29/1995	105	23.97	6.8	<0.02
14631	9/29/1995	139	31.03	7.4	1.2
14594	9/30/1994	235	18.21	11.0	3.5
14594	9/29/1995	326	12.96	8.6	4.8
14587	9/30/1994	257	56.66	10.1	0.6
14587	9/28/1995	259	59.72	7.8	<0.02
14588	9/30/1994	162	25.57	11.0	0.9
14589	9/30/1994	N.A.	N.A.	N.A.	N.A.
14588	9/28/1995	206	26.84	9.8	0.25
14590	9/30/1994	N.A.	12.22	N.A.	N.A.
14573	9/29/1994	202	12.00	10.0	1.9
14573	9/28/1995	190	11.77	8.7	1.1
14571	9/28/1994	174	9.44	10	2.8
14571	9/28/1995	199	16.31	9.0	3.8
14561	9/27/1994	114	5.30	10.1	1.3
14561	9/28/1995	106	4.62	7.8	<0.02
14552	9/26/1994	97	N.A.	10.8	0.6
14552	9/28/1995	103	N.A.	7.5	<0.02
14553	9/26/1994	96	5.63	10.2	0.1
14553	9/28/1995	90	5.38	7.9	0.12
14560	9/27/1994	69	7.44	10.5	0.9
14560	9/28/1995	67	3.65	8.8	0.04
14558	9/27/1994	115	15.53	10.9	0.7
14558	9/28/1995	123	14.83	7.8	<0.02
14557	9/27/1994	81	14.11	10.8	0.8
14557	9/28/1995	90	14.80	8.7	0.13
14554	9/26/1994	82	15.90	10.2	1.2
14555	9/26/1994	263	5.95	10.2	1.0
14554	9/28/1995	80	15.60	7.6	0.03

14569	9/28/1994	97	16.32	10.0	0.5
14569	9/28/1995	105	15.78	7.7	<0.02
14556	9/27/1994	97	18.00	9.4	1.2
14556	9/28/1995	105	17.58	8.2	0.46
14632	9/28/1995	80	16.51	7.6	0.26
14626	9/29/1994	204	6.50	7.5	0.8
14626	9/27/1995	65	48.40	8.1	0.26
14632	9/27/1995	219	7.15	8.6	0.07
N.A.	10/3/1995	N.A.	35.22	N.A.	N.A.
N.A.	10/3/1995	105	16.07	8.0	0.05
N.A.	10/3/1995	146	N.A.	8.9	1.5
N.A.	10/4/1995	189	12.39	8.1	0.16
N.A.	10/4/1995	120	N.A.	7.6	0.04
N.A.	10/4/1995	122	16.89	8.3	0.88
N.A.	10/4/1995	169	24.75	10.2	4.6
N.A.	10/4/1995	N.A.	14.55	N.A.	N.A.
N.A.	10/4/1995	250	23.82	7.6	1.0
N.A.	10/4/1995	150	14.89	8.8	1.4
N.A.	10/4/1995	108	12.49	8.4	<0.02
N.A.	10/4/1995	94	21.21	7.7	<0.02
N.A.	10/4/1995	118	41.33	7.3	<0.02
N.A.	10/3/1995	75	72.43	8.1	0.4
N.A.	10/3/1995	N.A.	90.40	N.A.	N.A.
N.A.	10/3/1995	N.A.	N.A.	N.A.	<0.02
N.A.	10/3/1995	N.A.	N.A.	N.A.	3.0
14616	9/27/1994	149	11.46	9.0	0.3
14616	10/2/1995	159	25.28	9.3	0.04
14592	10/2/1995	163	22.52	9.6	7.3
14575	9/29/1994	110	20.11	10.0	0.6
14575	10/3/1995	107	21.51	7.4	0.02
14574	9/29/194	N.A.	20.42	N.A.	N.A.
14574	10/3/1995	N.A.	21.24	N.A.	N.A.
14564	9/27/1994	101	23.64	10.0	1.3
14564	10/3/1995	102	24.50	7.1	0.05
14565	9/27/1994	149	17.95	10.9	0.6
14565	10/2/1995	155	17.90	11.1	N.A.
14563	9/27/1994	1229	11.26	10.0	N.A.
14563	10/2/1995	1348	13.93	7.1	0.02
14562	9/27/1994	122	7.14	10.1	0.9
14562	10/3/1995	114	8.37	8.3	0.38
14584	9/30/1994	176	15.5	11.0	0.7
14584	10/3/1995	179	16.07	8.6	<0.02
14583	9/30/1994	95	6.03	10.0	1.6
14583	10/2/1995	100	10.26	8.0	<0.02
14724	10/3/1995	223	10.80	12.3	4.5
14722	10/2/1995	323	10.50	15.4	5.4
14721	10/3/1995	349	14.22	10.4	7.2
14725	10/3/1995	185	8.00	7.6	<0.02
Note: N.A. = Not Available					

Table 7. Results from La Pine On-Site Monitoring Well Testing

Site ID	Well ID	Date	NH4 As N (mg/L)	Nitrate-Nitrite As N (mg/L)	TKN (mg/L)	TN (mg/L)	Chloride (mg/L)	Fecal Coliform	Notes
17348-G	1206	6/5/2001	0.02	4.15	0.5	4.65	9.8	2	
17348-G	1206	9/5/2001	0.02	15.3	0.3	15.6	22	1	
17348-G	1206	11/30/2001	0.03	12.1	0.2	12.3	19	1	TKN is est.
17348-G	1206	3/4/2002	0.1	8.7	0.1	8.8	16	1	TKN <0.2
17348-G	1206	6/3/2002	0.01	21.5	0.2	21.7	25	1	Ammonia <0.02
17348-G	1206	9/4/2002	0.01	20.6	0.2	20.8	24	1	Ammonia <0.02
17348-G	1206	11/18/2002	0.01	21.8	0.1	21.9	23	1	Ammonia <0.02, TKN <0.2
17348-G	1206	3/4/2003	0.01	15.9	0.3	16.2	16	1	NH4AsN <0.02
17348-G	1206	6/2/2003	0.01	20.7	0.1	20.8	20	1	NH4<0.02, TKN<0.2
17348-G	1206	9/16/2003	0.01	19.6	0.3	19.9	19	1	NH4AsN<0.02
17348-G	2004	11/30/2001	0.16	0.18	0.5	0.68	9.5	1	TKN est - sample analysis exceeded holding time
17348-G	2004	3/4/2002	0.2	0.3	0.7	1	11	1	
17348-G	2005	3/7/2001	0	0.02	0.1	0.12	1.8	0	BOD5 is estimate; TKN <0.2
17348-G	2005	3/7/2001	0.02	0.02	0.1	0.12	2	0	BOD5 dilution 3 not run due to insufficient sample. duplicate QA reading; T <0.2
17348-G	2005	6/5/2001	0.06	0.15	0.1	0.25	2	2	TKN <0.2
17348-G	2005	9/5/2001	0.02	0.24	0.1	0.34	1.8	1	TKN <0.2
17348-G	2005	11/28/2001	0.03	0.46	0.1	0.56	1.8	1	TKN <0.2
17348-G	2005	3/4/2002	0	0.1	0.1	0.2	2	1	TKN <0.2
17348-G	2005	6/3/2002	0.01	1.07	0.1	1.17	2.8	1	Ammonia <0.02; TKN <0.2
17348-G	2005	9/4/2002	0.01	0.8	0.1	0.9	3.4	1	Ammonia <0.02, TKN<0.2
17348-G	2005	11/18/2002	0.01	0.41	0.1	0.51	2.8	1	Ammonia <0.02, TKN <0.2

17348-G	2005	3/4/2003	0.01	0.59	0.1	0.69	3.5	1	NH4AsN <0.02, TKN <0.2
17348-G	2005	6/2/2003	0.01	1.57	0.1	1.67	4	1	NH4<0.02, TKN<0.2
17348-G	2005	9/16/2003	0.01	5.05	0.1	5.15	9.7		NH4AsN<0.02, TKN<0.2
17348-G	2005	9/30/2003						2	Bacteria Re-sample
17348-G	2005	9/30/2003						2	QA Duplicate; Bacteria Re-sample
55344-H	2007	9/26/2001	0	0.0056	0.1	0.1	3.9	1	TKN <0.2
55344-H	2007	12/17/2001	0.05	0	0.1	0.1	3.6	1	TKN <0.2
55344-H	2007	3/27/2002	0.1	0	0.1	0.1	4.3	1	TKN <0.2
55344-H	2007	5/21/2002							
55344-H	2007	6/25/2002	0.02	0.01	0.4	0.41	4.8		
55344-H	2007	8/28/2002							
55344-H	2007	9/24/2002	0.03	0.01	0.1	0.11	3.9	1	TKN < 0.2
55344-H	2007	12/18/2002	0.01	0.0088	0.3	0.3088	3.8	1	NH4<0.02, pH is est.
55344-H	2007	3/25/2003	0.02	0.0126	0.1	0.1126	3.9	1	TKN <0.2
55344-H	2007	6/25/2003	0.02	0.0303	0.1	0.1303	3.9	1	TKN<0.2
55344-H	2007	9/2/2003	0.01	0.0075	0.1	0.1075	4	1	NH4AsN<0.02, TKN<0.2
55344-H	2008	9/26/2001	0	0.33	0.2	0.53	4		
55344-H	2008	10/3/2001						2	Bacteria Re-sample
55344-H	2008	10/3/2001						2	Bacteria Re-sample; QA Duplicate
55344-H	2008	12/17/2001	0	0.24	0.3	0.54	3.7	1	
55344-H	2008	3/27/2002	0	0.2	0.1	0.3	4.4	2	TKN <0.2
55344-H	2008	5/21/2002							
55344-H	2008	6/25/2002	0.02	0.15	0.2	0.35	4.5	1	

55344-H	2008	8/28/2002							
55344-H	2008	9/24/2002	0.03	0.12	0.1	0.22	8.9	1	TKN < 0.2
55344-H	2008	12/18/2002	0.01	0.0985	0.2	0.2985	3.1	1	NH4<0.02, pH is est.
55344-H	2008	3/25/2003	0.04	0.106	0.1	0.206	3.2	1	TKN <0.2
55344-H	2008	6/25/2003	0.01	0.0955	0.1	0.1955	3.2	1	Ammonia<0.02, TKN<0.2
55344-H	2008	9/2/2003	0.01	0.0583	0.1	0.1583	3.3	1	NH4AsN<0.02, TKN<0.2
55344-H	2009	9/26/2001	0	4.32	0.3	4.62	14		BOD5 is estimate.
55344-H	2009	10/3/2001						2	Bacteria Re-sample
55344-H	2009	12/17/2001	0	4.16	0.3	4.46	12	2	
55344-H	2009	3/27/2002	23	65.9	32	97.9	37	400	
55344-H	2009	3/27/2002	0	3.6	0.3	3.9	10	2	
55344-H	2009	5/21/2002							
55344-H	2009	6/25/2002	0.03	3.42	0.4	3.82		1	chloride test void
55344-H	2009	8/28/2002							
55344-H	2009	9/24/2002	0.03	3.22	0.3	3.52	14	1	
55344-H	2009	12/18/2002	0.02	2.99	0.3	3.29	11	1	pH is est.
55344-H	2009	3/25/2003	0.01	2.94	0.3	3.24	10	1	NH4AsN <0.02
55344-H	2009	6/24/2003	0.03	2.61	0.1	2.71	12	1	TKN<0.2
55344-H	2009	9/2/2003	0.01	2.63	0.1	2.73	14	1	NH4AsN<0.02, TKN<0.2
54858-R	2011	3/14/2001	0.03	0.04	0.1	0.14	17	2	TKN <0.2
54858-R	2011	6/13/2001	0	0.04	0.1	0.14	15	2	TKN <0.2
54858-R	2011	9/11/2001	0	0.04	0.1	0.14	16	1	TKN <0.2
54858-	2011	12/3/2001	0	0	0.1	0.1	14	1	TKN <0.2 est.

R									
54858-R	2011	3/13/2002	0	0	0.1	0.1	16	1	TKN <0.2
54858-R	2011	6/12/2002	0.01	0.04	0.1	0.14	16	1	TKN <0.2, ammonia <0.02
54858-R	2011	9/11/2002	0.01	0.06	0.1	0.16	16	1	Ammonia <0.02, TKN<0.2
54858-R	2011	12/2/2002	0.01	0.4	0.1	0.5	14	1	Ammonia <0.02, TKN <0.2
54858-R	2011	3/11/2003	0.02	2.89	0.1	2.99	19	1	TKN <0.2
54858-R	2011	6/11/2003	0.01	2.96	0.1	2.96	17	1	Ammonia<0.02, TKN<0.2
54858-R	2011	9/2/2003	0.01	3.05	0.4	3.45	18	1	NH4AsN<0.02
54858-R	2012	6/13/2001	0	0.03	0.1	0.13	6.3	2	TKN <0.2
54858-R	2012	9/11/2001	0	0.05	0.1	0.15	8	1	TKN <0.2
54858-R	2012	3/13/2002	0	0.1	0.1	0.2	23	1	TKN <0.2
54858-R	2012	6/12/2002	0.01	0.53	0.1	0.63	6.9	1	TKN <0.2, ammonia <0.02
54858-R	2012	9/11/2002	0.03	0.71	0.1	0.81	5.2	1	TKN<0.2
54858-R	2012	12/2/2002							
54858-R	2012	3/11/2003	0.01	1.47	0.1	1.57	5.7	1	NH4AsN <0.02, TKN <0.2
54858-R	2012	6/11/2003	0.01	1.61	0.1	1.61	5.6	1	Ammonia<0.02, TKN<0.2
54858-R	2013	6/13/2001	0.03	0.11	0	0.11	7.5	2	
54858-R	2013	9/11/2001	0	0.19	0.1	0.29	7.6	1	TKN <0.2
54858-R	2013	12/5/2001	0	0.09	0.1	0.19	6.9	1	TKN <0.2 est.
54858-R	2013	3/13/2002	0	0.2	0.1	0.3	7.1	1	TKN <0.2
54858-R	2013	6/12/2002	0.01	0.15	0.1	0.25	8	1	TKN <0.2, ammonia <0.02
54858-R	2013	9/11/2002	0.01	0.51	0.1	0.61	9.2	1	Ammonia <0.02, TKN<0.2
54858-R	2013	12/2/2002	0.01	0.04	0.1	0.14	8.9	1	Ammonia <0.02, TKN <0.2

54858-R	2013	3/11/2003	0.01	0.0856	0.1	0.1856	10	1	NH4AsN <0.02, TKN <0.2
54858-R	2013	6/11/2003	0.01	0.104	0.1	0.104	12	1	Ammonia<0.02, TKN<0.2
54858-R	2013	9/2/2003	0.01	0.345	0.1	0.445	12	1	NH4AsN<0.02, TKN<0.2
17299-H	2015	3/4/2002	0.1	0.1	0.4	0.5	1.6	1	
17299-H	2015	6/5/2002	0.01	0.03	0.4	0.43	1.7	1	ammonia <0.02
17299-H	2015	9/4/2002	0.02	0.18	0.3	0.48	1.7	1	
17299-H	2015	11/18/2002	0.04	0.06	0.3	0.36	1.8	1	
17299-H	2015	3/4/2003	0.03	0.067	0.4	0.467	1.7	1	
17299-H	2015	6/2/2003	0.01	0.0215	0.3	0.3215	2	1	NH4<0.02
17299-H	2015	9/10/2003	0.01	0.0589	0.2	0.2589	2.6	1	NH4AsN<0.02
17299-H	2016	9/6/2001	0	0.04	0.1	0.14	0	1	TKN <0.2
17299-H	2016	6/5/2002	0.01	0.01	0.1	0.11	0.7	1	TKN <0.2, ammonia <0.02
17299-H	2016	9/4/2002	0.01	0.05	0.1	0.15	0.5		Ammonia <0.02, TKN<0.2
17299-H	2016	9/11/2002						2	
17299-H	2016	11/18/2002							Well dry, depth >7.02
17299-H	2016	3/4/2003	0.03	0.133	0.1	0.233	1.2		TKN <0.2
17299-H	2016	3/11/2003						2	bacteria re-sample
17299-H	2016	3/11/2003						2	QA Duplicate; bacteria resample
17299-H	2016	6/2/2003	0.01	0.0584	0.1	0.1584	1	2	NH4<0.02
17299-H	2016	9/10/2003	0.01	0.0291	0.1	0.1291	0.6	2	TKN<0.2, NH4AsN<0.02
17299-H	2017	3/8/2001	0.05	3.13	0.3	3.43	11	2	
17299-H	2017	6/7/2001	0.03	3.51	0.2	3.71	12	2	QA Duplicate
17299-	2017	6/7/2001	0.03	3.55	0.1	3.65	12	2	TKN <0.2

H									
17299-H	2017	9/6/2001	0.03	2.1	0.2	2.3	13	1	
17299-H	2017	3/4/2002	0	4.9	0.3	5.2	15	1	
17299-H	2017	6/5/2002	0.04	3.42	0.1	3.52	12	1	QA duplicate - TKN <0.2
17299-H	2017	6/5/2002	0.03	3.41	0.1	3.51	12	1	TKN <0.2
17299-H	2017	9/4/2002	0.01	0.52	0.1	0.62	7.5	1	Ammonia <0.02, TKN<0.2
17299-H	2017	11/18/2002	0.02	0.18	0.1	0.28	5.4	1	TKN <0.2
17299-H	2017	3/4/2003	0.01	6.57	0.3	6.87	13	1	NH4AsN <0.02
17299-H	2017	6/2/2003	0.01	5.35	0.3	5.65	6.8	1	NH4<0.02
17299-H	2017	9/10/2003	0.01	0.0989	0.1	0.1989	4	1	TKN<0.2, NH4AsN<0.02
53110-A	2027	3/20/2001	0	0.87	0.1	0.97	3.9	2	QA duplicate; TKN <0.2
53110-A	2027	3/20/2001	0.02	0.87	0.1	0.97	3.9	2	TKN <0.2
53110-A	2027	6/19/2001	0.02	0.09	0.1	0.19	3.7	2	TKN <0.2
53110-A	2027	9/18/2001	0.02	0.97	0.1	1.07	3.6	1	TKN <0.2
53110-A	2027	12/10/2001	0	0.98	0.5	1.48	8.6	1	TKN is est.
53110-A	2027	3/19/2002	0	1.8	0.1	1.9	2.8	1	TKN <0.2
53110-A	2027	6/18/2002	0.01	2.2	0.1	2.3	2.9	1	TKN <0.2, ammonia <0.02
53110-A	2027	9/18/2002	0.01	2.29	0.1	2.39	3.2	1	Ammonia <0.02, TKN<0.2
53110-A	2027	12/10/2002	0.01	2.33	0.1	2.43	3.8	1	Ammonia <0.02, TKN <0.2
53110-A	2027	3/18/2003	0.01	2.21	0.3	2.51	3.3	1	NH4AsN <0.02
53110-A	2027	6/17/2003	0.02	2.91	0.1	3.01	3.2	1	TKN<0.2
53110-A	2027	9/16/2003	0.01	2.94	0.1	3.04	2.9	1	NH4AsN<0.02, TKN<0.2
53110-A	2028	3/20/2001	0	0.7	0.1	0.8	1.9	2	TKN <0.2

53110-A	2028	3/19/2002	0	0.9	0.3	1.2	10	1	
53110-A	2029	12/10/2001	0	0.87	0.1	0.97	2.6	1	TKN is est.
53110-A	2029	3/19/2002	0	0.7	0.1	0.8	1.8	1	TKN <0.2
53110-A	2029	6/18/2002	0.03	1.09	0.1	1.19	2.8	1	TKN <0.2
53110-A	2029	9/18/2002	0.01	0.98	0.1	1.08	2.6	1	Ammonia <0.02, TKN<0.2
53110-A	2029	12/10/2002	0.01	0.654	0.1	0.754	2.4	1	Ammonia <0.02, TKN <0.2
53110-A	2029	3/18/2003	0.02	0.513	0.2	0.713	2.4	1	
53110-A	2029	6/17/2003	0.03	0.462	0.1	0.562	4.4	1	TKN<0.2
53110-A	2029	9/16/2003	0.01	0.631	0.1	0.731	4.6	1	NH4AsN<0.02, TKN<0.2
53110-A	2029	9/23/2003						2	Bacteria Re-sample
53110-A	2029	9/23/2003						2	QA Duplicate
17186-H3	2033	3/13/2001	0	2.41	0.1	2.51	2.9	2	TKN <0.2
17186-H3	2033	6/12/2001	0.02	0.58	0.1	0.68	2.2	2	TKN <0.2
17186-H3	2033	9/11/2001	0	0.67	0.1	0.77	2.3	1	TKN <0.2
17186-H3	2033	12/3/2001	0.02	1.42	0.1	1.52	2.6	1	TKN <0.2 est.
17186-H3	2033	3/13/2002	0	2.4	0.1	2.5	13	1	TKN <0.2
17186-H3	2033	6/11/2002	0.01	2.82	0.1	2.92	7.6	1	TKN <0.2, ammonia <0.02
17186-H3	2033	9/10/2002	0.01	2.79	0.1	2.89	5.5	1	Ammonia <0.02, TKN<0.2
17186-H3	2033	12/2/2002	0.01	3.96	0.1	4.06	5.3	1	Ammonia <0.02, TKN <0.2
17186-H3	2033	3/11/2003	0.01	3.01	0.1	3.11	9.6	1	NH4AsN <0.02, TKN <0.2
17186-H3	2033	6/10/2003	0.01	4.28	0.1	4.38	10	1	NH4<0.02, TKN<0.2
17186-H3	2033	9/17/2003	0.01	3.81	0.1	3.91	6.7	1	NH4AsN<0.02, TKN<0.2
52386-	2055	3/20/2001	0.03	7.02	0.1	7.12	9.5	2	TKN <0.2

M									
52386-M	2055	9/18/2001	0	3.52	0.1	3.62	5.2	1	TKN <0.2
52386-M	2055	12/11/2001	0	3.93	0.1	4.03	5.3	1	TKN <0.2 est
52386-M	2055	3/18/2002	0	6.9	0.1	7	9.2	1	TKN <0.2
52386-M	2055	6/17/2002	0.01	6.49	0.4	6.89	9.2	1	ammonia <0.02
52386-M	2055	9/17/2002	0.01	6.78	0.3	7.08	7.6	1	Ammonia <0.02, pH is est.
52386-M	2055	12/9/2002	0.01	6.67	0.7	7.37	6.8	1	Ammonia <0.02
52386-M	2055	3/17/2003	0.02	9.24	0.1	9.34	9.2	1	TKN <0.2
52386-M	2055	6/16/2003	0.04	8.78	0.1	8.88	9.5	1	TKN<0.2
52386-M	2055	9/15/2003	0.01	7.77	0.1	7.87	8	1	TKN<0.2, NH4AsN<0.02
52386-M	2056	3/20/2001	0	3.38	0.2	3.58	15	2	
52386-M	2056	3/18/2002	0	2.5	0.1	2.6	12	1	TKN <0.2
52386-M	2057	3/20/2001	0.05	0.33	0.1	0.43	3.2	2	TKN <0.2
52386-M	2057	6/19/2001	0.02	0.73	0.1	0.83	2.8	2	QA duplicate; TKN <0.2
52386-M	2057	6/19/2001	0	0.73	0.4	1.13	2.9	2	
52386-M	2057	9/18/2001	0.04	0.53	0.1	0.63	2.2	1	TKN <0.2
52386-M	2057	12/11/2001	0.02	0.5	0.1	0.6	2.1	1	TKN <0.2 est.
52386-M	2057	12/11/2001	0.03	0.5	0.1	0.6	1.9	1	QA duplicate; (TKN <0.2 est.)
52386-M	2057	3/18/2002	0	0.5	0.1	0.6	1.9	1	TKN <0.2
52386-M	2057	6/17/2002	0.01	0.17	0.1	0.27	1.8	1	TKN <0.2, ammonia <0.02
52386-M	2057	9/17/2002	0.01	0.99	0.1	1.09	2.6	1	Ammonia <0.02, TKN<0.2, pH is est.
52386-M	2057	12/9/2002	0.01	1.09	0.1	1.19	3.5	1	Ammonia <0.02, TKN <0.2
52386-M	2057	3/17/2003	0.01	0.834	0.1	0.934	3	1	Ammonia <0.02, TKN <0.2

52386-M	2057	6/16/2003	0.01	0.2	0.1	0.3	1.9	1	Ammonia<0.02, TKN<0.2
52386-M	2057	9/15/2003	0.01	0.146	0.1	0.246	1.9	1	TKN<0.2, NH4AsN<0.02
50663-F	2063	3/27/2001	0	2.39	0.1	2.49	22	2	
50663-F	2063	6/26/2001	0.02	2.29	0.1	2.39	24	2	
50663-F	2063	9/25/2001	0	1.88	0.1	1.98	20	1	
50663-F	2063	9/25/2001	0	1.86	0.1	1.96	20	1	
50663-F	2063	12/19/2001	0	5.47	0.1	5.57	24	1	
50663-F	2063	12/19/2001	0	5.4	0.1	5.5	23	1	
50663-F	2063	3/25/2002	0	5	0.1	5.1	23	1	
50663-F	2063	6/24/2002	0.01	4.12	0.1	4.22	23	1	
50663-F	2063	9/23/2002	0.02	4.49	0.1	4.59	27	1	
50663-F	2063	12/16/2002	0.01	4.65	0.1	4.75	31	1	
50663-F	2063	3/24/2003	0.01	5.14	0.1	5.24	26	1	
50663-F	2063	6/23/2003	0.01	3.53	0.1	3.63	21	1	
50663-F	2063	11/18/2003	0.02	5.16	0.1	5.26	21	1	
50663-F	2064	3/27/2001	0.04	0.8	0.1	0.9	12	2	
50663-F	2064	6/26/2001	0.02	1.18	0.1	1.28	12	2	
50663-F	2064	9/25/2001	0	4.12	0.1	4.22	12	1	
50663-F	2064	12/19/2001	0	4.8	0.1	4.9	16	1	
50663-F	2064	3/25/2002	0	5	0.1	5.1	17	1	
50663-F	2064	6/24/2002	0.01	5.11	0.1	5.21	18	1	
50663-F	2064	9/23/2002	0.04	4.77	0.1	4.87	18	1	
50663-F	2064	12/16/2002	0.01	3.8	0.1	3.9	18	1	

50663-F	2064	3/24/2003	0.01	3.28	0.1	3.38	15	1
50663-F	2064	6/23/2003	0.01	2.27	0.1	2.37	13	1
50663-F	2064	9/22/2003	0.03	1.69	0.1	1.79	12	1
50663-F	2064	11/18/2003	0.01	1.49	0.1	1.59	11	1
50663-F	2065	3/27/2001	0.02	0.35	0.1	0.45	4.1	2
50663-F	2065	6/26/2001	0.03	0.49	0.1	0.59	4.3	2
50663-F	2065	9/25/2001	0	0.78	0.1	0.88	5	
50663-F	2065	10/3/2001						2
50663-F	2065	12/19/2001	0	1.37	0.1	1.47	7.4	1
50663-F	2065	3/25/2002	0	1	0.1	1.1	6.7	2
50663-F	2065	6/24/2002	0.01	1.18	0.1	1.28	7.8	1
50663-F	2065	9/23/2002	0.01	1.45	0.1	1.55	7.5	
50663-F	2065	9/25/2002						2
50663-F	2065	12/16/2002	0.01	2.88	0.1	2.98	13	2
50663-F	2065	3/24/2003	0.01	3.35	0.1	3.45	18	1
50663-F	2065	6/23/2003	0.01	2.5	0.1	2.6	14	2
50663-F	2065	9/22/2003	0.01	2.86	0.3	3.16	13	2
50663-F	2065	11/17/2003						
52330-S	2067	3/27/2001	0.03	2.25	0.1	2.35	4.5	2
52330-S	2067	6/26/2001	0.02	2.16	0.1	2.26	4.4	2
52330-S	2067	9/26/2001	0	2.18	0.2	2.38	4.3	1
52330-S	2067	12/19/2001	0	2.22	0.1	2.32	4.3	1
52330-S	2067	3/26/2002	0	2.3	0.1	2.4	4.4	1

52330-S	2067	6/25/2002	0.01	2.41	0.1	2.51	5.5	1
52330-S	2067	9/25/2002	0.01	2.66	0.1	2.76	4.8	1
52330-S	2067	12/17/2002	0.01	2.6	0.1	2.7	5	1
52330-S	2067	3/24/2003	0.01	2.77	0.1	2.87	5.1	1
52330-S	2067	6/24/2003	0.01	2.81	0.1	2.91	5.4	1
52330-S	2067	9/23/2003	0.01	2.88	0.1	2.98	5.5	1
52330-S	2067	11/18/2003	0.01	2.98	0.1	3.08	5.8	1
52330-S	2068	3/27/2001	0.02	3.73	0.1	3.83	7.8	2
52330-S	2068	6/26/2001	0	4	0.1	4.1	9.4	2
52330-S	2068	9/26/2001	0	3.9	0.1	4	9.2	1
52330-S	2068	9/26/2001	0	4	0.3	4.3	9.2	1
52330-S	2068	12/19/2001	0	3.33	0.1	3.43	8.3	1
52330-S	2068	3/26/2002	0	3.7	0.1	3.8	8.4	1
52330-S	2068	6/25/2002	0.04	4.44	0.1	4.54	12	1
52330-S	2068	9/25/2002	0.01	3.78	0.1	3.88	9.9	1
52330-S	2068	12/17/2002	0.01	3.27	0.1	3.37	8.9	1
52330-S	2068	3/24/2003	0.02	3.15	0.3	3.45	8.8	1
52330-S	2068	6/24/2003	0.01	3.03	0.1	3.13	10	1
52330-S	2068	9/23/2003	0.01	6.47	0.1	6.57	12	1
52330-S	2068	11/18/2003	0.01	9.62	0.1	9.72	13	1
52330-S	2069	3/27/2001	0.03	0.74	0.1	0.84	2.1	2
52330-S	2069	3/27/2001	0.02	0.74	0.1	0.84	2.5	2
52330-S	2069	6/26/2001	0	0.7	0.1	0.8	1.9	2

52330-S	2069	6/26/2001	0	0.7	0.1	0.8	1.9	2	
52330-S	2069	9/26/2001	0	0.96	0.1	1.06	1.5	1	
52330-S	2069	12/19/2001	0	0.97	0.1	1.07	2	1	
52330-S	2069	3/26/2002	0	0.9	0.1	1	2.3	1	
52330-S	2069	6/25/2002	0.01	0.95	0.1	1.05	2.5	1	
52330-S	2069	9/25/2002	0.01	1.06	0.1	1.16	1.5	1	
52330-S	2069	12/17/2002	0.01	1.06	0.1	1.16	1.6	1	
52330-S	2069	3/24/2003	0.03	0.974	0.1	1.074	2	1	
52330-S	2069	6/24/2003	0.01	0.955	0.1	1.055	2	1	
52330-S	2069	9/23/2003	0.01	0.962	0.1	1.062	1.4	1	
52330-S	2069	11/18/2003	0.01	1.04	0.1	0	1.5	1	
52509-P	2071	3/21/2001	0	0.62	0.1	0.72	0.9	2	TKN <0.2
52509-P	2071	9/19/2001	0.04	0.56	0.1	0.66	1	2	TKN <0.2
52509-P	2071	12/12/2001	0	0.58	0.1	0.68	20	1	
52509-P	2071	3/18/2002	0	0.6	0.1	0.7	0.8	1	TKN <0.2
52509-P	2071	6/18/2002	0.01	0.68	0.1	0.78	1	1	TKN <0.2, ammonia <0.02
52509-P	2071	9/16/2002	0.01	0.63	0.1	0.73	1	2	Ammonia <0.02, TKN<0.2
52509-P	2071	12/9/2002	0.01	0.706	0.1	0.806	1	1	Ammonia <0.02, TKN <0.2
52509-P	2071	3/17/2003	0.01	0.726	0.1	0.826	1	1	Ammonia <0.02, TKN <0.2
52509-P	2071	6/17/2003	0.03	0.746	0.1	0.846	1.4	1	TKN<0.2
52509-P	2071	9/9/2003	0.01	0.798	0.1	0.898	1.4	1	TKN<0.2, NH4AsN<0.02
52509-P	2072	3/21/2001	0	0.9	0.1	1	0.7	2	TKN<0.2
52509-P	2072	12/12/2001	0	1	0.1	1.1	21	1	TKN <0.2 est.

52509-P	2072	3/18/2002	0	1.1	0.1	1.2	0.7	1	TKN <0.2
52509-P	2073	3/21/2001	0.03	2.5	0.1	2.6	6.9	2	TKN <0.2
52509-P	2073	6/19/2001	0.03	2.57	0.2	2.77	9.2	2	
52509-P	2073	9/19/2001	0.03	3.57	1	4.57	14	1	QA Duplicate; TKN <0.2
52509-P	2073	9/19/2001	0	3.53	0.1	3.63	14	1	TKN <0.2
52509-P	2073	12/11/2001	0	4.6	0.1	4.7	17	1	NH4-N <.02, TKN <0.2 est.
52509-P	2073	3/18/2002	0	2.8	0.1	2.9	8.3	1	TKN <0.2
52509-P	2073	6/18/2002	0.02	2.96	0.1	3.06	8.2	1	TKN <0.2
52509-P	2073	9/16/2002	0.01	5.19	0.1	5.29	14	1	Ammonia <0.02, TKN<0.2
52509-P	2073	12/10/2002	0.01	6.07	0.3	6.37	14	1	Ammonia <0.02
52509-P	2073	3/17/2003	0.02	5.38	0.1	5.48	14	1	TKN <0.2
52509-P	2073	6/17/2003	0.02	6.13	0.1	6.23	16	1	TKN<0.2
52509-P	2073	9/9/2003	0.01	6.81	0.1	6.91	13	1	TKN<0.2, NH4AsN<0.02
52724-R	2079	12/12/2001	0	6.9	0.1	7	11		TKN <0.2 est.
52724-R	2079	12/18/2001						2	Bacteria Re-sample
52724-R	2079	3/19/2002	0	7.1	0.1	7.2	21	2	TKN <0.2
52724-R	2079	6/18/2002	0.01	7.2	0.1	7.3	10	2	TKN <0.2, ammonia <0.02
52724-R	2079	9/17/2002	0.01	7.33	0.1	7.43	11	2	Ammonia <0.02, TKN<0.2, pH is est.
52724-R	2079	12/10/2002	0.01	7.36	0.2	7.56	11	1	Ammonia <0.02
52724-R	2079	3/17/2003	0.03	7.64	0.4	8.04	12	1	
52724-R	2079	6/18/2003	0.03	8.1	0.1	8.2	12	1	TKN<0.2
52724-R	2079	9/9/2003	0.05	8.29	0.1	8.39	12	1	TKN<0.2
52724-R	2080	3/21/2001	0	2.8	0.1	2.9	7.8	2	TKN <0.2

52724-R	2080	6/20/2001	0.02	2.95	0.1	3.05	7.7	2	TSS void; TKN <0.2
52724-R	2080	6/20/2001	0	2.97	0.1	3.07	7.7	2	QA Duplicate; TKN <0.2
52724-R	2080	9/19/2001	0	3.61	0.2	3.81	7.3	1	
52724-R	2080	12/18/2001	0	4.8	0.2	5	7.9	1	
52724-R	2080	3/19/2002	0	5.5	0.1	5.6	8.4	1	TKN <0.2
52724-R	2080	6/18/2002	0.01	5.26	0.1	5.36	7.6	1	TKN <0.2, ammonia <0.02
52724-R	2080	9/17/2002	0.01	5.18	0.1	5.28	8	1	Ammonia <0.02, TKN<0.2, pH is est.
52724-R	2080	12/10/2002	0.01	6.06	0.2	6.26	8.7	1	Ammonia <0.02
52724-R	2080	3/17/2003	0.01	5.49	0.8	6.29	7.4	1	Ammonia <0.02
52724-R	2080	6/17/2003	0.04	4.98	0.1	5.08	6.5	1	TKN<0.2
52724-R	2080	9/9/2003							all tests cancelled, DRY, depth >23.22
52724-R	2081	3/21/2001	0	4.25	0.1	4.35	4.7	2	TKN <0.2
52724-R	2081	6/20/2001	0	4.03	0.1	4.13	4.4	2	TSS void; TKN <0.2
52724-R	2081	9/19/2001	0	3.43	0.1	3.53	4.6	1	TKN <0.2
52724-R	2081	12/14/2001	0	2.9	0.1	3	4.8	1	QA dupl - TKN <.2 est.
52724-R	2081	12/14/2001	0.02	2.9	0.1	3	4.9	1	TKN <0.2 est.
52724-R	2081	3/19/2002	0	2.5	0.1	2.6	3.9	1	TKN <0.2
52724-R	2081	6/18/2002	0.01	2.43	0.1	2.53	3.1	1	TKN <0.2, ammonia <0.02
52724-R	2081	9/17/2002	0.01	2.3	0.1	2.4	3	1	Ammonia <0.02, TKN<0.2, pH is est.
52724-R	2081	12/10/2002	0.01	2.18	0.1	2.28	2.9	1	Ammonia <0.02, TKN <0.2
52724-R	2081	3/17/2003	0.01	2.58	0.1	2.68	3	1	Ammonia <0.02, TKN <0.2
52724-R	2081	6/17/2003	0.01	3.24	0.1	3.34	3.1	1	NH4<0.02, TKN<0.2
52724-	2081	9/9/2003							all tests cancelled, DRY, depth >23.47

R									
17346-B	2083	12/5/2001	0.61	0	0.7	0.7	1	1	TKN is estimate.
17346-B	2083	3/13/2002	0.6	0	0.8	0.8	2	1	
17346-B	2085	3/14/2001	0	4.23	0.1	4.33	4.3	2	TKN <0.2
17346-B	2085	6/13/2001	0.02	3.09	0.2	3.29	2	2	
17346-B	2085	9/11/2001	0.03	2.67	0.1	2.77	1.8	1	TKN <0.2
17346-B	2085	12/5/2001	0	3.73	0.1	3.83	1.6	1	TKN < 0.2
17346-B	2085	3/13/2002	0	5	0.1	5.1	1.4	1	TKN <0.2
17346-B	2085	6/11/2002	0.01	4.36	0.2	4.56	2.4	1	ammonia <0.02
17346-B	2085	9/11/2002	0.01	8.54	0.2	8.74	2.1	1	Ammonia <0.02
17346-B	2085	12/2/2002	0.01	5.05	0.2	5.25	63	1	Ammonia <0.02
17346-B	2085	3/10/2003	0.01	11.9	0.4	12.3	15	1	NH4AsN <0.02
17346-B	2085	6/3/2003	0.01	7.78	0.1	7.88	3.9	1	NH4<0.02, TKN<0.2
17346-B	2085	9/17/2003	0.01	6.5	0.1	6.6	5.1	1	NH4AsN<0.02, TKN<0.2
17346-B	2086	3/14/2001	0.02	0.01	0.1	0.11	3.1	2	TKN <0.2
17346-B	2086	3/14/2001	0.03	0.01	0.1	0.11	3.1	2	QA Duplicate; TKN <0.2
17346-B	2086	6/13/2001	0	0	0.2	0.2	1.9	2	
17346-B	2086	6/13/2001	0.02	0	0.2	0.2	1.9	2	(QA reading duplicate)
17346-B	2086	9/12/2001	0	0	0.1	0.1	1.3	1	TKN <0.2
17346-B	2086	9/12/2001	0	0	0.1	0.1	1.3	1	QA duplicate; TKN <0.2
17346-B	2086	12/5/2001	0	0	0.1	0.1	1.3	1	TKN <0.2
17346-B	2086	12/5/2001	0	0	0.1	0.1	1.3	1	QA Duplicate; TKN < 0.2 est.
17346-B	2086	3/13/2002	0	0	0.1	0.1	3	1	TKN <0.2

17346-B	2086	3/13/2002	0	0	0.1	0.1	3.2	1	QA Duplicate - TKN <0.2
17346-B	2086	6/11/2002	0.01	0.01	0.3	0.31	4.2	1	ammonia <0.02
17346-B	2086	9/9/2002	0.01	0	0.2	0.2	3.2	1	Ammonia <0.02, Nitrate<0.005
17346-B	2086	12/2/2002	0.01	0.03	0.1	0.13	2.2	1	Ammonia <0.02, TKN <0.2
17346-B	2086	3/10/2003	0.01	0.0109	0.1	0.1109	3.6	1	NH4AsN <0.02, TKN <0.2
17346-B	2086	6/3/2003	0.01	0.0068	0.1	0.1068	3.9	1	NH4<0.02, TKN<0.2
17346-B	2086	9/17/2003	0.01	0.0831	0.1	0.1831	1.6	1	NH4AsN<0.02, TKN<0.2
50880-M	2098	9/22/2003	0.01	0.0025	0.2	0.2025	7.6	1	NH4AsN<0.02, Nitrate/nitrite<0.005
50880-M	2099	5/29/2001	0.02	0.02			2.9		Well development; No result reported for TKN
50880-M	2099	5/29/2001	0.03	0.02			2.8		QA Duplicate; No result reported for TKN
50880-M	2099	9/25/2001	0	0.03	0.1	0.13	3.2	1	TKN <0.2
50880-M	2099	12/18/2001	0	0.03	0.1	0.13	4	1	TKN <.2
50880-M	2099	3/25/2002	0	0.28	0.1	0.38	2	1	TKN <0.2, DO <0.1
50880-M	2099	5/21/2002							
50880-M	2099	6/24/2002	0.01	0.51	0.1	0.61	3.1	1	TKN <0.2, NH4<0.02
50880-M	2099	8/27/2002							
50880-M	2099	9/24/2002	0.01	0.61	0.1	0.71	3	1	ammonia < 0.02; TKN < 0.2
50880-M	2099	12/16/2002	0.01	0.372	0.1	0.472	2.5	1	NH4<0.02, TKN<0.2
50880-M	2099	3/24/2003	0.02	0.381	0.1	0.481	2.4	1	TKN <0.2, D.O. <0.1
50880-M	2099	6/23/2003	0.01	0.495	0.1	0.595	2.8	1	Ammonia<0.02, TKN<0.2
50880-M	2099	9/22/2003	0.01	0.525	0.1	0.625	2.5	1	NH4AsN<0.02, TKN<0.2
17271-P	2131	9/21/2001	0.01	0.77	0.1	0.87	140		NH4 <0.02; TKN <0.2
17271-	2131	2/19/2002	0	3.5	0.4	3.9	35	1	

P									
17271-P	2131	5/14/2002	0.01	2.38	0.1	2.48	69	1	TKN <0.2, ammonia <0.02
17271-P	2131	6/19/2002							
17271-P	2131	7/15/2002							
17271-P	2131	8/20/2002	0.01	1.45	0.3	1.75	24	1	ammonia <0.02
17271-P	2131	9/18/2002							
17271-P	2131	10/15/2002							
17271-P	2131	11/6/2002	0.02	0.63	0.1	0.73	19	1	TKN <0.2
17271-P	2131	12/10/2002							
17271-P	2131	1/14/2003							
17271-P	2131	2/10/2003	0.03	0.483	0.1	0.583	18	1	TKN <0.2
17271-P	2131	5/20/2003	0.01	0.881	0.1	0.981	15	1	NH4<0.02, TKN<0.2
17271-P	2131	8/25/2003	0.03	0.494	0.3	0.794	30	1	
17271-P	2131	11/3/2003	0.08	1.28	0.1	1.38	31	1	TKN<0.2
17271-P	2132	9/21/2001	0.01	0.63	0.1	0.73	30		NH4<0.02, TKN <0.2
17271-P	2132	2/19/2002	0	11.6	0.3	11.9	15	1	
17271-P	2132	5/14/2002	0.01	6.05	0.6	6.65	18	1	ammonia <0.02
17271-P	2132	6/19/2002							
17271-P	2132	7/15/2002							
17271-P	2132	8/20/2002	0.01	3.4	0.1	3.5	25	1	TKN <0.2, ammonia <0.02
17271-P	2132	9/18/2002							
17271-P	2132	10/15/2002							
17271-P	2132	11/6/2002	0.02	2.85	0.1	2.95	35	1	TKN <0.2

17271-P	2132	12/10/2002							
17271-P	2132	1/14/2003							
17271-P	2132	2/10/2003	0.01	3.66	0.1	3.76	34	1	NH4AsN <0.02, TKN <0.2
17271-P	2132	5/20/2003	0.01	7.04	0.1	7.14	32	1	NH4<0.02, TKN<0.2
17271-P	2132	8/25/2003	0.01	5.91	0.1	6.01	46	1	NH4AsN<0.02, TKN<0.2
17271-P	2132	11/3/2003	0.01	6.34	0.1	6.44	62	1	NH4AsN<0.02, TKN<0.2
17271-P	2133	9/21/2001	0.04	4.14	0.1	4.24	22		TKN <0.2
17271-P	2133	2/19/2002	0	3.3	0.3	3.6	23	1	
17271-P	2133	5/14/2002	0.06	2.63	0.1	2.73	25	1	TKN <0.2
17271-P	2133	6/19/2002							
17271-P	2133	7/15/2002							
17271-P	2133	8/20/2002	0.01	2.12	0.1	2.22	25	1	TKN <0.2, ammonia <0.02
17271-P	2133	9/18/2002							
17271-P	2133	10/15/2002							
17271-P	2133	11/6/2002	0.01	1.3	0.1	1.4	22	1	Ammonia <0.02, TKN <0.2
17271-P	2133	12/10/2002							
17271-P	2133	1/14/2003							
17271-P	2133	2/10/2003	0.01	1.21	0.1	1.31	150	1	NH4AsN <0.02, TKN <0.2
17271-P	2133	5/20/2003	0.01	2.3	0.1	2.4	85	1	NH4<0.02, TKN<0.2
17271-P	2133	8/25/2003	0.01	1.9	0.1	2	64	1	NH4AsN<0.02, TKN<0.2
17271-P	2133	11/3/2003	0.03	2.3	0.1	2.4	48	1	TKN<0.2
55583-T	2138	9/27/2001							Background/well development; Unable to establish flow for samples.
55583-T	2138	2/26/2002	0.2	9.2	0.9	10.1	28	1	

55583-T	2138	5/22/2002	0.04	18.4	0.5	18.9	170	1	
55583-T	2138	6/25/2002							
55583-T	2138	7/29/2002							
55583-T	2138	8/26/2002	0.15	24.2	0.7	24.9	98		
55583-T	2138	8/28/2002						2	Bacteria Re-sample
55583-T	2138	9/25/2002							
55583-T	2138	10/21/2002							
55583-T	2138	11/12/2002							
55583-T	2138	2/25/2003	0.05	5.34	0.5	5.84	20	2	
55583-T	2138	5/21/2003	0.05	55.5	1.1	56.6	400	2	
55583-T	2138	8/27/2003	0.05	35.4	0.1	35.5	120	1	TKN<0.2
55583-T	2138	11/5/2003							
55583-T	2139	9/27/2001	0.14	9.27			29		Background/well development; No result reported for TKN
55583-T	2139	2/26/2002	0.1	26.6	0.7	27.3	37	1	
55583-T	2139	5/22/2002	0.18	25.6	0.1	25.7	29	1	TKN <0.2
55583-T	2139	6/25/2002							
55583-T	2139	7/29/2002							
55583-T	2139	8/26/2002	0.16	13	0.6	13.6	35	1	
55583-T	2139	9/25/2002							
55583-T	2139	10/21/2002							
55583-T	2139	11/12/2002	0.1	29	0.3	29.3	42	1	
55583-T	2139	2/25/2003	0.07	36	0.1	36.1	40	1	TKN <0.2
55583-T	2139	5/19/2003	0.02	31.1	0.1	31.2	33	1	TKN<0.2

55583-T	2139	8/27/2003	0.13	20.9	0.1	21	39	1	TKN<0.2
55583-T	2139	11/5/2003	0.07	32.3	0.1	32.4	57	1	TKN<0.2
55583-T	2140	9/27/2001	0.04	26.8			70		D.O. <0.1; Background/well development; No result reported for TKN
55583-T	2140	9/27/2001	0.04	26.9			69		QA Duplicate; Background/well development; DO<0.1; No result reported f TKN
55583-T	2140	2/26/2002	0.05	207	1.5	208.5	280	1	
55583-T	2140	5/22/2002	0.04	7.09	0.3	7.39	23	1	
55583-T	2140	6/25/2002							
55583-T	2140	7/29/2002							
55583-T	2140	8/26/2002	0.09	87.7	1.6	89.3	160	1	
55583-T	2140	9/25/2002							
55583-T	2140	10/21/2002							
55583-T	2140	11/12/2002	0.08	94.4	1.31	95.71	160	1	
55583-T	2140	2/25/2003	0.08	67.5	0.1	67.6	100	1	TKN <0.2
55583-T	2140	5/19/2003	0.04	8.12	0.1	8.22	24	1	TKN<0.2
55583-T	2140	8/27/2003	0.09	71.6	1.4	73	130	1	TKN is est.
55583-T	2140	11/5/2003	0.04	59.4	0.1	59.5	120	1	TKN<0.2
52081-Y	2142	10/10/2001	0.01	0.33			2.8		well development; NH4 <0.02; No TKN result reported
52081-Y	2142	10/10/2001	0.01	0.33			2.9		QA Duplicate; Background/well development; NH4 <0.02; No TKN result reported
52081-Y	2142	2/11/2002	0.02	0.4	0.1	0.5	2.7	1	TKN <0.2
52081-Y	2142	5/6/2002	0.01	0.79	0.6	1.39	2.2	1	Ammonia <0.02
52081-Y	2142	7/22/2002							
52081-Y	2142	8/12/2002	0.01	1.45	0.1	1.55	2.6	1	TKN is <0.2 est., ammonia <0.02
52081-	2142	9/9/2002							

Y									
52081-Y	2142	11/4/2002	0.01	1.18	0.4	1.58	2.5	1	Ammonia <0.02
52081-Y	2142	12/3/2002							
52081-Y	2142	2/3/2003	0.01	0.954	0.4	1.354	2.6	1	NH4 <0.02
52081-Y	2142	5/20/2003	0.03	1.13	0.1	1.23	2.4	1	TKN<0.2
52081-Y	2142	8/26/2003	0.01	1.61	0.3	1.91	3.9	1	NH4AsN<0.02
52081-Y	2143	10/10/2001	0.01	0.78			15		Background/well development; NH4 <0.02; No TKN result reported
52081-Y	2143	2/11/2002	0	0.9	0.1	1	23	1	TKN <0.2; TKN < 0.2
52081-Y	2143	5/6/2002	0.01	0.8	0.1	0.9	33	1	Ammonia <0.02, TKN <0.2
52081-Y	2143	7/22/2002							
52081-Y	2143	8/12/2002	0.01	0.87	1	1.87	48	1	TKN is est., ammonia <0.02
52081-Y	2143	9/9/2002							
52081-Y	2143	11/4/2002	0.02	0.93	0.1	1.03	52	1	TKN <0.2
52081-Y	2143	12/3/2002							
52081-Y	2143	2/3/2003	0.01	0.993	0.1	1.093	47	1	NH4 <0.02, TKN <0.2
52081-Y	2143	5/20/2003	0.01	1.08	0.1	1.18	53	1	NH4<0.02, TKN<0.2
52081-Y	2143	8/26/2003	0.01	1.19	0.3	1.49	47	1	NH4AsN<0.02
52081-Y	2144	10/10/2001	0.02	1.35			31		Background/well development; No TKN result reported
52081-Y	2144	2/11/2002	0	1.25	0.1	1.35	39	1	TKN < 0.2
52081-Y	2144	5/6/2002	0.01	1.07	0.1	1.17	75	1	Ammonia <0.02, TKN <0.2
52081-Y	2144	7/22/2002							
52081-Y	2144	8/12/2002	0.03	1.28	0.3	1.58	97	1	TKN is est.
52081-Y	2144	9/9/2002							

52081-Y	2144	11/4/2002	0.01	1.35	0.1	1.45	89	1	Ammonia <0.02, TKN <0.2
52081-Y	2144	12/3/2002							
52081-Y	2144	2/3/2003	0.01	1.44	0.4	1.84	77	1	NH4 <0.02
52081-Y	2144	5/20/2003	0.03	1.55	0.1	1.65	67	1	TKN<0.2
52081-Y	2144	8/26/2003	0.01	1.37	0.1	1.47	29	1	NH4AsN<0.02, TKN<0.2
53444-L	2170	11/15/2001	0.06	0.01		0.01	4.8		Background/well development; No TKN result reported.
53444-L	2170	2/5/2002	0	0	0.4	0.4	5.8		
53444-L	2170	2/11/2002						2	Bacteria Re-sample
53444-L	2170	4/30/2002	0.02	0	0.3	0.3	5.2	2	
53444-L	2170	8/5/2002	0.05	0.01	0.3	0.31	5.1	2	D.O. <0.1
53444-L	2170	9/4/2002							
53444-L	2170	10/2/2002							
53444-L	2170	10/29/2002	0.05	0.01	0.2	0.21	5.7	2	
53444-L	2170	11/19/2002							
53444-L	2170	2/5/2003	0.04	0.0147	0.1	0.1147	5.3	1	TKN<0.2
53444-L	2170	5/5/2003	0.05	0.0124	0.2	0.2124	5.3	1	
53444-L	2170	8/5/2003	0.03	0.0096	0.3	0.3096	5.4	1	
53444-L	2170	10/28/2003	0.03	0.0181	0.3	0.3181	5.4	1	
53444-L	2171	11/15/2001	0.04	0.01			6.6		Background/well development; No TKN result reported.
53444-L	2171	2/5/2002	0	0	0.1	0.1	7	1	
53444-L	2171	4/30/2002	0.04	0.01	0.7	0.71	6.9	1	
53444-L	2171	8/5/2002	0.07	0.01	0.2	0.21	6.2	1	
53444-	2171	9/4/2002							

L									
53444-L	2171	10/2/2002							
53444-L	2171	10/29/2002	0.03	0.02	0.2	0.22	6.4	1	
53444-L	2171	11/19/2002							
53444-L	2171	2/5/2003	0.02	0.02	0.7	0.72	6.4	1	
53444-L	2171	5/5/2003	0.01	0.0084	0.3	0.3084	6	1	Ammonia <0.02
53444-L	2171	8/5/2003	0.01	0.0582	0.2	0.2582	6.2	1	Ammonia<0.02
53444-L	2171	10/28/2003	0.01	0.137	0.1	0.237	6.2	1	NH4AsN<0.02, TKN<0.2
53444-L	2172	11/16/2001	0.01	0.06			1.8		Background/well development; NH4 <0.02; No TKN result reported
53444-L	2172	2/5/2002	0	0.1	0.3	0.4	2.6	1	
53444-L	2172	4/30/2002	0.01	0.07	0.1	0.17	2.3	1	Ammonia <0.02; TKN <0.2
53444-L	2172	8/5/2002	0.03	0.06	0.1	0.16	2	1	TKN <0.2
53444-L	2172	9/4/2002							
53444-L	2172	10/2/2002							
53444-L	2172	10/29/2002	0.01	0.09	0.1	0.19	2	1	Ammonia <0.02, TKN <0.2
53444-L	2172	11/19/2002							
53444-L	2172	2/5/2003	0.02	0.906	0.3	1.206	3	1	
53444-L	2172	5/5/2003	0.01	0.812	0.1	0.912	5.9	1	Ammonia <0.02, TKN <0.2
53444-L	2172	8/5/2003	0.01	0.757	0.1	0.857	10	1	Ammonia<0.02, TKN<0.2
53444-L	2172	10/28/2003	0.01	3.83	0.2	4.03	15		NH4AsN<0.02
53444-L	2172	10/29/2003						2	Bacteria Re-sample
55726-H2	2202	3/13/2001	0.03	3.72	0.1	3.82	6.7	2	TKN <0.2
55726-H2	2202	3/13/2001	0.03	3.76	0.1	3.86	6.5	2	duplicate; TKN <0.2

55726-H2	2202	6/12/2001	0	2.48	0.1	2.58	5.6	2	TKN <0.2
55726-H2	2202	9/11/2001	0	1.81	0.1	1.91	3.9	1	TKN <0.2
55726-H2	2202	12/3/2001	0.02	1.59	0.1	1.69	3	1	BOD5 <0.2 est; TKN <0.2
55726-H2	2202	3/12/2002	0	2.8	0.3	3.1	6	1	
55726-H2	2202	6/11/2002	0.01	3.36	0.1	3.46	5.9	1	TKN <0.2, ammonia <0.02
55726-H2	2202	9/10/2002	0.02	5.87	0.1	5.97	6.3	1	TKN<0.2
55726-H2	2202	12/2/2002	0.01	4.29	0.1	4.39	5.2	1	Ammonia <0.02, TKN <0.2
55726-H2	2202	3/11/2003	0.01	6.19	0.1	6.29	8.2	1	NH4AsN <0.02, TKN <0.2
55726-H2	2202	6/10/2003	0.01	5.17	0.4	5.57	6.7	1	NH4<0.02
55726-H2	2202	9/10/2003	0.1	5.63	0.3	5.93	7	1	
55726-H2	2203	6/12/2001	0	5.91	0.1	6.01	14	2	TKN <0.2
55726-H2	2203	9/11/2001	0.03	5.84	0.3	6.14	20	1	
55726-H2	2203	12/3/2001	0.02	3.31	0.1	3.41	8.1	1	TKN <0.2 est.
55726-H2	2203	12/3/2001	0.03	3.32	0.1	3.42	7.7	1	QA duplicate
55726-H2	2203	3/12/2002	0	8.4	0.3	8.7	24	1	
55726-H2	2203	6/11/2002	0.01	6.48	0.3	6.78	27	1	ammonia <0.02
55726-H2	2203	9/10/2002	0.01	4.22	0.1	4.32	9.8	1	Ammonia <0.02, TKN<0.2
55726-H2	2203	12/2/2002	0.01	3.84	0.1	3.94	7.2	1	Ammonia <0.02, TKN <0.2
55726-H2	2203	3/11/2003	0.01	5.67	0.2	5.87	21	1	NH4AsN <0.02
55726-H2	2203	6/10/2003	0.01	4.1	0.1	4.2	18	1	NH4<0.02, TKN<0.2
55726-H2	2203	9/10/2003	0.01	4.81	0.1	4.91	15	1	TKN<0.2, NH4AsN<0.02
55726-H2	2204	11/2/1999	0.06	5.11	0.2	5.31		2	
55726-H2	2204	1/5/2000	0.02	9.07	0.4	9.47		2	

55726-H2	2204	3/1/2000	0.07	23.1	0.8	23.9		2	can't find data sheet.
55726-H2	2204	5/4/2000	0	5.12	0.3	5.42	12	2	not in data files.
55726-H2	2204	7/10/2000	0	18.3	0.3	18.6	18	600	not in data files.
55726-H2	2204	9/6/2000							Dry to bottom of screen, no samples
55726-H2	2204	11/15/2000							Unable to sample; insufficient recharge
55726-H2	2204	3/13/2001	0.02	15.7	0.4	16.1	39	2	
55726-H2	2204	4/10/2001	0	12.1	0.8	12.9	34	2	
55726-H2	2204	4/10/2001	0	12.1	0.8	12.9	34	2	QA dupl.
55726-H2	2204	5/8/2001	0	10.9	0.4	11.3	35	2	
55726-H2	2204	6/12/2001	0	7.24	0.4	7.64	23	2	QA duplicate
55726-H2	2204	6/12/2001	0	7.25	0.3	7.55	23	2	
55726-H2	2204	7/17/2001	0	10.7	0.3	11	25	1	QA duplicate
55726-H2	2204	7/17/2001	0	10.8	0.3	11.1	25	1	
55726-H2	2204	8/14/2001	0	8.09	0.3	8.39	27	1	
55726-H2	2204	8/14/2001	0	8.08	0.4	8.48	28	1	QA Duplicate
55726-H2	2204	9/11/2001	0	8.09	0.4	8.49	34		
55726-H2	2204	9/18/2001						2	Bacteria Re-Sample
55726-H2	2204	10/9/2001	0	6.1	0.3	6.4	32	2	
55726-H2	2204	10/9/2001	0	6.1	0.3	6.4	32	2	QA Duplicate
55726-H2	2204	1/14/2002	0	4.6	0.4	5	46	2	BOD <1; TSS <1
55726-H2	2204	3/12/2002	0	6.9	0.5	7.4	58	2	BOD5 <1.0; TSS <1
55726-H2	2204	5/7/2002	0.01	7.74	0.5	8.24	41	2	NH4 <0.02
55726-H2	2204	6/11/2002	0.01	6.92	0.5	7.42	38	2	TSS <1, BOD5<1.0, ammonia <0.02

55726-H2	2204	7/15/2002	0.02	5.07	0.4	5.47	31	1	TSS <1, BOD5<1.0
55726-H2	2204	7/15/2002	0.01	5.07	0.5	5.57	31	1	QA duplicate, TSS <1, ammonia <0.02, BOD5<1.0
55726-H2	2204	9/10/2002	0.03	5.94	0.4	6.34	28	1	BOD5<1.0, TSS<1
55726-H2	2204	11/5/2002	0.03	6.75	0.4	7.15	36	1	BOD5 <1.0, TSS<1
55726-H2	2204	12/2/2002	0.01	6.71	0.4	7.11	31	1	BOD5 <1.0, TSS<1 Ammonia <0.02
55726-H2	2204	12/2/2002	0.01	6.69	0.4	7.09	31	1	QA Duplicate; BOD5 <1.0, TSS<1 Ammonia <0.02
55726-H2	2204	1/13/2003	0.03	5.64	0.5	6.14	38	1	BOD5 <1.0, TSS <1
55726-H2	2204	3/11/2003	0.03	6.92	0.7	7.62	59	1	BOD5<1.0, TSS<1
55726-H2	2204	5/13/2003	0.01	4.94	0.1	5.04	27	1	BOD5<1.0, TSS <1 Ammonia <0.02, TKN <0.2
55726-H2	2204	5/13/2003	0.02	4.91	0.1	5.01	27	1	QA Duplicate; BOD5<1.0, TSS <1, TKN <0.2
55726-H2	2204	6/10/2003	0.01	4.71	0.3	5.01	20	1	BOD5<1.0, TSS<1, NH4<0.02
55726-H2	2204	6/10/2003	0.01	4.72	0.2	4.92	21	1	QA Duplicate; BOD5<1.0, TSS<1, NH4<0.02
55726-H2	2204	7/15/2003	0.01	4.5	0.1	4.6	14	1	BOD5<1.0, TSS<1, Ammonia<0.02, TKN<0.2
55726-H2	2204	7/15/2003	0.01	4.49	0.2	4.69	15	1	QA Duplicate; BOD5<1.0, TSS<1, Ammonia<0.02
55726-H2	2204	9/10/2003	0.01	4.96	0.1	5.06	14	1	BOD5 is est., TKN<0.2, NH4AsN<0.02, TSS<1
55726-H2	2204	9/10/2003	0.01	4.96	0.1	5.06	14	1	TKN<0.2, NH4AsN<0.02, TSS<1, BOD5<1
17186-H3	2205	3/13/2001	0.03	1.64	0.1	1.74	3.1	2	TKN <0.2
17186-H3	2205	6/12/2001	0	1.07	0.1	1.17	2.8	2	TKN <0.2
17186-H3	2205	12/3/2001	0.02	3.24	0.1	3.34	4	1	TKN is est.
17186-H3	2205	3/13/2002	0	3.1	0.1	3.2	4.1	1	TKN <0.2
17186-H3	2205	6/11/2002	0.01	1.98	0.1	2.08	4.5	1	TKN <0.2, ammonia <0.02
17186-H3	2205	9/10/2002	0.06	2.87	0.1	2.97	16	1	TKN<0.2
17186-H3	2205	3/11/2003	0.05	4.41	0.1	4.51	8.3	1	TKN <0.2

17186-H3	2205	6/10/2003	0.01	2.8	0.1	2.9	7.4	1	NH4<0.02, TKN<0.2
17186-H3	2205	9/17/2003	0.01	1.71	0.1	1.81	8.5	1	NH4AsN<0.02, TKN<0.2
17186-H3	2206	3/13/2001	0.04	0.59	0.1	0.69	2.2	2	TKN <0.2
17186-H3	2206	6/12/2001	0	0.97	0	0.97	3.4	2	
17186-H3	2206	9/11/2001	0	1.61	0.1	1.71	3.3	1	TKN <0.2
17186-H3	2206	12/3/2001	0	1.16	0.1	1.26	2.5	1	TKN is est.
17186-H3	2206	3/13/2002	0	2.5	0.1	2.6	5.4	1	TKN <0.2
17186-H3	2206	6/11/2002	0.01	1.6	0.1	1.7	6.1	1	TKN <0.2, ammonia <0.02
17186-H3	2206	9/10/2002	0.01	2.9	0.1	3	9.3	1	Ammonia <0.02, TKN<0.2
17186-H3	2206	12/2/2002	0.01	2.55	0.1	2.65	6.2	1	Ammonia <0.02, TKN <0.2
17186-H3	2206	3/11/2003	0.01	1.3	0.1	1.4	6.4	1	NH4AsN <0.02, TKN <0.2
17186-H3	2206	6/10/2003	0.01	2.11	0.1	2.21	8.1	1	NH4<0.02, TKN<0.2
17186-H3	2206	9/17/2003	0.01	1.58	0.1	1.68	7.1	1	NH4AsN<0.02, TKN<0.2
53110-A	2212	5/1/2002	0.04	0.38	0.6	0.98	5.6		Background/well development
53110-A	2212	6/18/2002	0.04	1.07	0.1	1.17	4.8	1	TKN <0.2
53110-A	2212	9/18/2002	0.03	1.24	0.1	1.34	4.4	1	TKN<0.2
53110-A	2212	12/10/2002	0.03	0.948	0.3	1.248	4.5	1	
53110-A	2212	3/18/2003	0.03	1.45	0.5	1.95	4.3	1	
53110-A	2212	6/17/2003	0.06	1.56	0.1	1.66	4.1	1	TKN<0.2
53110-A	2212	9/16/2003	0.01	1.3	0.1	1.4	4.1	1	NH4AsN<0.02, TKN<0.2
17346-B	2213	5/16/2002	0.47	0.01			12		No TKN reported.
17346-B	2213	6/11/2002	0.56	0.01	1.1	1.11	6.2	1	
17346-B	2213	9/11/2002	0.71	0.01	1	1.01	1.7		

17346-B	2213	12/3/2002	0.76	0.01	1	1.01	2		No bacteria sample due to extreme slow flow.
17346-B	2213	3/10/2003	0.66	0.0158	0.8	0.8158	2.3	1	
17346-B	2213	6/3/2003	0.67	0.0317	0.8	0.8317	3	1	
17346-B	2213	9/17/2003	0.7	1.4	0.7	2.1	1.9	1	
17348-G	2214	5/2/2002	0.02	11	0.3	11.3	15		Well Development
17348-G	2214	5/2/2002	0.03	11	0.2	11.2	15		Well Development; QA DUPLICATE
17348-G	2214	6/3/2002	0.04	14.1	0.3	14.4	16	1	
17348-G	2214	9/4/2002	0.01	11.8	0.3	12.1	16	1	Ammonia <0.02
17348-G	2214	11/18/2002	0.04	16.3	0.1	16.4	19	1	TKN <0.2
17348-G	2214	3/4/2003	0.01	18.3	0.1	18.4	21	1	NH4AsN <0.02, TKN <0.2
17348-G	2214	6/2/2003	0.01	16.6	0.1	16.7	20	1	NH4<0.02, TKN<0.2
17348-G	2214	9/16/2003	0.01	15.6	0.2	15.8	20	1	NH4AsN<0.02
52386-M	2217	5/9/2002	0.02	0.71	0.2	0.91	4.2		Well development
52386-M	2217	6/17/2002	0.01	1.37	0.1	1.47	4.9		TKN <0.2, ammonia <0.02
52386-M	2217	9/17/2002	0.01	2.46	0.2	2.66	8.8	2	Ammonia <0.02, pH is est.
52386-M	2217	12/9/2002	0.02	3.17	0.2	3.37	10	2	
52386-M	2217	3/17/2003	0.02	2.24	0.1	2.34	6.6	1	TKN <0.2
52386-M	2217	6/16/2003	0.02	2.32	0.1	2.42	7.5	1	TKN<0.2
52386-M	2217	9/15/2003	0.01	2.96	0.3	3.26	10	1	NH4AsN<0.02
52509-P	2220	5/2/2002	0.04	1.03	0.3	1.33	3.4		Well Development
52509-P	2220	6/18/2002	0.03	0.7	0.3	1		1	chloride test void
52509-P	2220	9/16/2002	0.01	0.98	0.1	1.08	0.9	1	Ammonia <0.02, TKN<0.2
52509-P	2220	12/9/2002	0.02	1.1	0.4	1.5	3.6	1	

52509-P	2220	3/17/2003	0.01	1.36	0.2	1.56	1.1	1	Ammonia <0.02
52509-P	2220	6/17/2003	0.02	1.52	0.1	1.62	0.8	1	TKN<0.2
52509-P	2220	9/9/2003	0.01	1.45	0.1	1.55	0.9	1	TKN<0.2, NH4AsN<0.02
15766-K	2003	9/28/2001	0.01	1.43			12		Background/well development; NH4 <0.02; No result reported for TKN
15766-K	2003	7/15/2002	0.01	3.67	0.1	3.77	28	1	KN <0.2, N<0.02
15766-K	2003	8/6/2002							
15766-K	2003	9/9/2002							
15766-K	2003	10/7/2002	0.02	7.62	0.1	7.72	67	1	chloride is estimate, TKN < 0.2
15766-K	2003	11/4/2002							
15766-K	2003	12/3/2002							
15766-K	2003	1/21/2003	0.01	3.81	0.2	4.01	19	1	Ammonia <0.02
15766-K	2003	2/11/2003							
15766-K	2003	3/10/2003							
15766-K	2003	4/21/2003	0.01	85.2	0.1	85.3	120	1	Ammonia <0.02, TKN <0.2
15766-K	2003	6/17/2003							
15766-K	2003	7/14/2003	0.04	5.48	0.1	5.58	63	1	TKN<0.2
15766-K	2003	10/7/2003	0.01	3.78	0.1	3.88	45	1	NH4AsN<0.02, TKN<0.2
15766-K	2003	2/9/2004							
15766-K	2003	5/17/2004							
52375-H	2019	3/28/2001	0.06	98.2	0.6	98.8	80	2	
52375-H	2019	3/28/2001	0.1	98.8	0.6	99.4	80	2	QA duplicate;
52375-H	2019	9/26/2001	0	100	0.5	100.5	87	1	BOD5 is estimate; TSS "void"
52375-H	2019	12/18/2001	0	91.8	0.6	92.4	75	1	

52375-H	2019	3/26/2002	0	109	0.1	109.1	79	1	TKN <0.2
52375-H	2019	6/24/2002	0.03	109	0.4	109.4	79	1	
52375-H	2019	9/25/2002	0.01	108	0.4	108.4	83	1	ammonia <0.02
52375-H	2019	12/17/2002	0.01	110	0.1	110.1	77	1	NH4<0.02, TKN<0.2
52375-H	2019	3/25/2003	0.03	101	0.1	101.1	76	1	TKN <0.2
52375-H	2019	6/24/2003	0.01	103	0.1	103.1	75	1	NH4<0.02, TKN<0.2
52375-H	2019	9/8/2003	0.01	97.2	0.1	97.3	77	1	TKN<0.2, NH4AsN<0.02
52375-H	2019	1/26/2004							
52375-H	2019	4/12/2004							
52375-H	2020	3/28/2001	0	0.04	0.1	0.14	1.2	2	TKN <0.2
52375-H	2020	6/26/2001	0.03	0.02	0.1	0.12	1.1	2	TKN <0.2
52375-H	2020	3/26/2002	0	0	0.1	0.1	1.1	1	TKN <0.2
52375-H	2020	6/24/2002	0.02	0.04	0.1	0.14	1.4	1	TKN <0.2
52375-H	2020	9/25/2002	0.01	0.04	0.1	0.14	1.5	1	ammonia < 0.02; TKN <0.2
52375-H	2020	12/17/2002							
52375-H	2020	3/25/2003	0.02	0.0365	0.1	0.1365	1.5	1	TKN <0.2
52375-H	2020	6/24/2003	0.03	0.0522	0.1	0.1522	1.4	1	TKN<0.2
52375-H	2020	9/8/2003	0.01	0.0442	0.1	0.1442	1.3	1	TKN<0.2, NH4AsN<0.02
52375-H	2020	1/26/2004							
52375-H	2020	4/12/2004							
52375-H	2021	3/28/2001	0.1	0.5	0.1	0.6	1.8	2	TKN <0.2
52375-H	2021	4/24/2001	0.05	0.5	0.1	0.6	1.7	2	alkalinity is estimate; TKN <0.2
52375-H	2021	5/22/2001	0	0.51	0.1	0.61	1.7	2	TKN <0.2

52375-H	2021	7/31/2001	0	0.56	0.1	0.66	1.7	1	TKN <0.2
52375-H	2021	8/28/2001	0.02	0.54	0.1	0.64	1.7	1	BOD5 <1.0 - TKN <0.2
52375-H	2021	8/28/2001	0	0.55	0.1	0.65	1.7	1	QA dupl reading; BOD5 <1.0, TKN <0.2
52375-H	2021	10/23/2001	0	0.65	0.1	0.75	1.5	1	BOD is <1.0; TKN is <0.2
52375-H	2021	11/19/2001	0	0.65	0.1	0.75	1.4	1	TKN <0.2
52375-H	2021	3/26/2002	0	1	0.1	1.1	1	1	TKN <0.2, TSS <1; BOD <1.0
52375-H	2021	4/22/2002	0.01	1.01	0.6	1.61	1.3	1	Ammonia <0.02; BOD <1
52375-H	2021	6/24/2002	0.03	1	0.1	1.1	1.3		TKN <0.2
52375-H	2021	9/25/2002	0.01	1.21	0.1	1.31	1.2	1	ammonia <0.02; TKN <0.2
52375-H	2021	12/17/2002	0.01	1.5	0.1	1.6	1.1	1	NH4<0.02, TKN<0.2
52375-H	2021	3/25/2003	0.03	1.63	0.1	1.73	1.6	1	TKN <0.2
52375-H	2021	6/24/2003	0.01	1.78	0.1	1.88	1	1	NH4<0.02, TKN<0.2
52375-H	2021	9/8/2003	0.01	1.83	0.1	1.93	0.9	1	TKN<0.2, NH4AsN<0.02
52375-H	2021	1/26/2004							
52375-H	2021	4/12/2004							
55635-I	2022	1/2/2002							Background/well development; No recharge, unable to obtain samples.
55635-I	2022	2/20/2002	0	0.1	0.2	0.3	2.4	1	
55635-I	2022	5/14/2002	0.01	0.28	0.1	0.38	5.4	1	TKN <0.2, ammonia <0.02
55635-I	2022	6/19/2002							
55635-I	2022	7/22/2002							
55635-I	2022	8/21/2002	0.03	0.06	0.1	0.16	1.7	1	TKN <0.2
55635-I	2022	9/18/2002							
55635-I	2022	10/14/2002							
55635-I	2022	11/5/2002							
55635-I	2022	12/10/2002							
55635-I	2022	2/11/2003	0.02	0.0622	0.1	0.1622	1.7	1	TKN <0.2
55635-I	2022	5/21/2003	0.01	0.135	0.1	0.235	5.3	1	NH4<0.02, TKN<0.2

55635-I	2022	8/11/2003	0.01	0.059	0.1	0.159	4.8	1	NH4AsN<0.02, TKN<0.2
55635-I	2022	11/3/2003							No Flow; no samples collected
55635-I	2022	3/29/2004							
55635-I	2022	6/21/2004							
55730-P	2032	10/30/2002							
55730-P	2032	11/19/2002							
55730-P	2032	1/7/2003	0.01	0.674	0.1	0.774	3	1	NH4<0.02, TKN<0.2
55730-P	2032	2/4/2003							
55730-P	2032	3/4/2003							
55730-P	2032	3/31/2003	0.01	0.614	0.1	0.714	2.6	1	Ammonia <0.02, TKN <0.2
55730-P	2032	6/11/2003							
55730-P	2032	7/15/2003	0.01	0.525	0.1	0.625	2.3	1	Ammonia<0.02, TKN<0.2
55730-P	2032	8/19/2003							
55730-P	2032	10/7/2003	0.01	0.556	0.1	0.656	1.9	1	NH4AsN<0.02, TKN<0.2
55730-P	2032	2/4/2004							
55730-P	2032	5/17/2004							
52655-C	2035	3/6/2001	0	0.01	0.1	0.11	7.3	2	BOD5 estimate due to insufficient depletion; TKN <0.2
52655-C	2035	6/5/2001	0.03	0	0.1	0.1	7.1	2	TKN <0.2
52655-C	2035	9/5/2001	0.02	0.0025	0.1	0.1025	7.4	1	Nitrate <0.005; TKN < 0.2
52655-C	2035	12/12/2001	0	0	0.1	0.1	5.7	1	TKN is <0.2 estimate
52655-C	2035	3/5/2002	0	0.01	0.1	0.11	5.5	1	TKN <0.2; D.O. <0.1
52655-C	2035	6/3/2002	0.06	0	0.4	0.4	4.4	1	
52655-C	2035	9/3/2002	0.04	0.01	0.1	0.11	5	1	TKN<0.2, D.O.<0.1
52655-C	2035	12/16/2002	0.03	0.0131	0.1	0.1131	6.1	1	TKN<0.2, D.O. <0.1
52655-	2035	3/3/2003	0.04	0.0059	0.1	0.1059	7.3	1	TKN <0.2, D.O. <0.1

C									
52655-C	2035	6/9/2003	0.02	0.007	0.1	0.107	6.5	1	TKN<0.2,D.O.<0.1
52655-C	2035	9/8/2003	0.03	0.0025	0.1	0.1025	6.5	1	TKN<0.2 Nitrate/Nitrite<.005
52655-C	2035	1/26/2004							
52655-C	2035	4/12/2004							
52655-C	2035	7/12/2004							
52655-C	2036	3/6/2001	0	0.95	0.1	1.05	1.5	2	TKN <0.2
52655-C	2036	6/5/2001	0	1.04	0.1	1.14	2	2	TKN <0.2
52655-C	2036	9/5/2001	0	0.55	0.1	0.65	1.7	1	TKN <0.2
52655-C	2036	12/12/2001	0.01	0.72	0.1	0.82	1.8	1	TKN is <0.2 Estimate
52655-C	2036	3/5/2002	0	0.84	0.1	0.94	2.6	1	TKN <0.2
52655-C	2036	6/3/2002	0.01	0.56	0.1	0.66	2.6	1	Ammonia <0.02; TKN <0.2
52655-C	2036	9/3/2002	0.01	0.64	0.1	0.74	2.7	1	Ammonia <0.02, TKN<0.2
52655-C	2036	12/16/2002	0.01	0.853	0.1	0.953	2.7	1	NH4<0.02, TKN<0.2
52655-C	2036	3/3/2003	0.02	0.793	0.1	0.893	3.2	1	TKN <0.2
52655-C	2036	6/9/2003	0.01	0.79	0.1	0.89	3.4	1	Ammonia<0.02, TKN<0.2
52655-C	2036	9/8/2003	0.02	1.57	0.1	1.67	3.1	1	TKN<0.2
52655-C	2036	1/26/2004							
52655-C	2036	4/12/2004							
52655-C	2036	7/12/2004				199998			
52655-C	2037	3/6/2001	0	2.93	0.3	3.23	10	2	
52655-C	2037	6/5/2001	0	2.39	0.2	2.59	8.7	2	
52655-C	2037	6/5/2001	0	2.37	0.3	2.67	8.6	2	QA duplicate
52655-	2037	9/5/2001	0	2.09	0.2	2.29	7.7	1	

C									
52655-C	2037	9/5/2001	0	2.07	0.3	2.37	7.7	1	QA Duplicate;
52655-C	2037	12/12/2001	0.02	1.96	0.4	2.36	7.6	1	TKN is est.
52655-C	2037	3/5/2002	0	1.9	0.3	2.2	8.1	1	
52655-C	2037	6/3/2002	0.01	1.59	0.1	1.69	7.8	1	Ammonia <0.02; TKN<0.2
52655-C	2037	9/3/2002	0.01	1.71	0.2	1.91	9.1	1	Ammonia <0.02
52655-C	2037	12/16/2002	0.01	2.27	0.3	2.57	8.5	1	NH4<0.02
52655-C	2037	3/3/2003	0.01	2.4	0.1	2.5	7.7	1	NH4AsN <0.02, TKN <0.2
52655-C	2037	6/9/2003	0.01	2.09	0.1	2.19	7	1	Ammonia<0.02, TKN<0.2
52655-C	2037	9/8/2003	0.01	1.97	0.2	2.17	7.7	1	NH4AsN<0.02
52655-C	2037	1/26/2004							
52655-C	2037	4/12/2004							
52655-C	2037	7/12/2004							
52588-P	2039	3/6/2001	0	0.92	0.1	1.02	4.1	2	TKN <0.2
52588-P	2039	6/5/2001	0	1.24	0.1	1.34	3.5	2	TKN <0.2
52588-P	2039	9/5/2001	0	1.06	0.1	1.16	3	1	TKN <0.2
52588-P	2039	12/12/2001	0	1.56	0.1	1.66	4.2	1	TKN is <0.2 estimate
52588-P	2039	3/5/2002	0	2.1	0.1	2.2	4.9	1	TKN <0.2
52588-P	2039	6/3/2002	0.04	1.58	1.4	2.98	3.2	1	
52588-P	2039	7/15/2002							
52588-P	2039	9/9/2002	0.05	1.4	0.3	1.7	3.3	1	
52588-P	2039	11/19/2002	0.01	2.03	0.1	2.13	4.9		Ammonia <0.02, TKN <0.2
52588-P	2039	12/9/2002						2	Bacteria Re-sample
52588-	2039	3/3/2003	0.01	2.03	0.1	2.13	5.7	2	NH4AsN <0.02, TKN <0.2

P									
52588-P	2039	6/2/2003	0.01	1.11	0.3	1.41	3.6	2	NH4<0.02
52588-P	2039	9/8/2003							all tests cancelled, DRY, depth >15.59
52588-P	2039	1/26/2004							Dry; depth >15.58
52588-P	2039	4/12/2004							
52588-P	2039	7/12/2004							
52588-P	2041	3/6/2001	0	0.01	0.1	0.11	2.3	2	TKN <0.2
52588-P	2041	6/5/2001	0.02	0.11	0.1	0.21	1.8	2	TKN <0.2
52588-P	2041	9/5/2001	0	0.43	0.2	0.63	1.4	1	BOD5 is <1
52588-P	2041	3/5/2002	0	0.7	0.1	0.8	1.6	1	TKN <0.2
52588-P	2041	6/3/2002	0.03	0.49	0.3	0.79	1.1	1	
52588-P	2041	7/15/2002							
52588-P	2041	9/9/2002							DRY - WaterDepth >15.18
52588-P	2041	11/19/2002							Well dry, depth >15.17
52588-P	2041	3/3/2003							depth >15.15
52588-P	2041	6/2/2003							depth >15.20
52588-P	2041	9/8/2003							all tests cancelled, DRY, depth >15.12
52588-P	2041	1/26/2004							Dry; depth >15.12
52588-P	2041	4/12/2004							DRY; depth >15.09
52588-P	2041	7/12/2004							dry, depth >14.75
16444-L	2043	11/30/2001	0.02	0.98	0.1	1.08	0.6	1	TKN is <0.2
16444-L	2043	3/11/2002	0	1.4	0.1	1.5	1.8	1	TKN <0.2
16444-L	2043	6/11/2002	0.01	1.01	0.1	1.11	0.9	1	TKN <0.2, ammonia <0.02
16444-	2043	8/12/2002							

L									
16444-L	2043	9/9/2002	0.01	1.18	0.1	1.28	2.4	1	Ammonia <0.02, TKN<0.2
16444-L	2043	12/3/2002	0.01	1.2	0.1	1.3	1.4	1	Ammonia <0.02, TKN <0.2
16444-L	2043	3/10/2003	0.01	1.15	0.1	1.25	1.3	1	NH4AsN <0.02
16444-L	2043	6/9/2003	0.01	1.25	0.1	1.35	1.4	1	Ammonia<0.02, TKN<0.2
16444-L	2043	9/24/2003	0.01	1.43	0.1	1.53	1.6	1	NH4AsN<0.02, TKN<0.2
16444-L	2043	1/26/2004							
16444-L	2043	7/12/2004	0.01	1.4	0.1	1.5	3.4	1	ammonia<0.02, TKN<0.2
16444-L	2044	11/30/2001	0.02	7.47	0.1	7.57	18	1	TKN is <0.2 est
16444-L	2044	3/11/2002	0	5.2	0.2	5.4	13	1	
16444-L	2044	6/11/2002	0.01	5.28	1.6	6.88	12	1	ammonia <0.02
16444-L	2044	8/12/2002							
16444-L	2044	9/9/2002	0.01	4.94	0.4	5.34	13	1	Ammonia <0.02
16444-L	2044	12/3/2002	0.01	5.6	0.1	5.7	19	1	Ammonia <0.02, TKN <0.2
16444-L	2044	3/10/2003	0.01	5.41	0.3	5.71	22	1	NH4AsN <0.02
16444-L	2044	6/9/2003	0.01	4.85	0.1	4.95	21	1	Ammonia<0.02, TKN<0.2
16444-L	2044	9/24/2003	0.01	5.9	0.1	6	24	1	NH4AsN<0.02, TKN<0.2
16444-L	2044	1/26/2004							
16444-L	2044	7/12/2004	0.01	4.93	0.1	5.03	13	1	ammonia<0.02, TKN<0.2
56083-M	2046	2/12/2002	0	10.8	0.1	10.9	22	1	TKN <0.2
56083-M	2046	5/7/2002	0.01	7.64	0.1	7.74	20	1	Ammonia <0.02; TKN <0.2
56083-M	2046	6/11/2002							
56083-M	2046	7/16/2002							
56083-	2046	8/13/2002	0.01	5.28	0.1	5.38	44	1	TKN <0.2 est., ammonia <0.02

M									
56083-M	2046	9/10/2002							
56083-M	2046	10/7/2002							
56083-M	2046	11/6/2002	0.01	6.47	0.1	6.57	19	1	Ammonia <0.02, TKN <0.2
56083-M	2046	2/10/2003	0.01	4.02	0.1	4.12	16	1	NH4AsN <0.02, TKN <0.2
56083-M	2046	5/6/2003	0.01	4.45	0.1	4.55	13	1	Ammonia <0.02, TKN <0.2
56083-M	2046	8/12/2003	0.01	6.38	0.1	6.48	11	1	Ammonia<0.02, TKN<0.2
56083-M	2046	10/28/2003	0.01	2.17	0.1	2.27	11	1	NH4AsN<0.02, TKN<0.2
56083-M	2046	5/24/2004							
55635-I	2050	1/2/2002							Background/well development; No re-charge, unable to obtain samples.
55635-I	2050	2/20/2002	0	0.2	0.1	0.3	1.5	1	TKN <0.2
55635-I	2050	5/14/2002	0.02	0.63	0.4	1.03	2.6	1	
55635-I	2050	6/19/2002							
55635-I	2050	7/22/2002							
55635-I	2050	8/21/2002	0.05	0.24	0.1	0.34	3.3	1	TKN <0.2
55635-I	2050	9/18/2002							
55635-I	2050	10/14/2002							
55635-I	2050	11/5/2002							
55635-I	2050	12/10/2002							
55635-I	2050	2/11/2003	0.01	0.0654	0.1	0.1654	2	1	NH4AsN <0.02, TKN <0.2
55635-I	2050	5/21/2003	0.02	0.078	0.1	0.178	1.8	1	TKN<0.2
55635-I	2050	8/11/2003	0.01	0.291	0.1	0.391	3.2	1	NH4AsN<0.02, TKN<0.2
55635-I	2050	11/3/2003							No Flow; no samples collected
55635-I	2050	3/29/2004							
55635-I	2050	6/21/2004							
17276-C	2087	2/4/2002	0	4.2	0.1	4.3	6.8	1	TKN <0.2
17276-C	2087	5/13/2002	0.01	0.96	0.1	1.06	11	1	TKN <0.2, ammonia <0.02
17276-C	2087	6/25/2002							
17276-	2087	7/22/2002							

C									
17276-C	2087	8/21/2002	0.07	0.67	0.1	0.77	32	1	TKN <0.2, BOD5 <1
17276-C	2087	9/17/2002							
17276-C	2087	10/1/2002							
17276-C	2087	10/29/2002	0.01	0.61	0.1	0.71	32	1	Ammonia <0.02, TKN <0.2
17276-C	2087	12/9/2002							
17276-C	2087	2/19/2003	0.04	3.83	0.1	3.93	20	1	TKN <0.2
17276-C	2087	5/12/2003	0.01	0.973	0.1	1.073	18	1	Ammonia <0.02, TKN <0.2
17276-C	2087	8/19/2003	0.01	1.71	0.1	1.81	23	1	NH4AsN<0.02, TKN<0.2
17276-C	2087	11/12/2003	0.01	2.2	0.1	2.3	22	1	Ammonia<0.02, TKN<0.2
17276-C	2087	6/7/2004							
16444-L	2089	5/30/2001	0.08	2			4.1		QA Duplicate; Well development; No result reported for TKN
16444-L	2089	5/30/2001	0.08	2.02			4		Well development; No result reported for TKN
16444-L	2089	11/30/2001	0.02	0.49	0.1	0.59	4	1	TKN is <0.2 est
16444-L	2089	3/11/2002	0	1	0.1	1.1	6.1	1	TKN <0.2
16444-L	2089	6/11/2002	0.01	1.94	0.1	2.04	7	1	TKN <0.2, ammonia <0.02
16444-L	2089	8/12/2002							
16444-L	2089	9/9/2002	0.01	3.58	0.3	3.88	8.5	1	Ammonia <0.02
16444-L	2089	12/3/2002	0.01	4.78	0.1	4.88	9.1	1	Ammonia <0.02, TKN <0.2
16444-L	2089	3/10/2003	0.01	4.83	0.2	5.03	8.7	1	NH4AsN <0.02
16444-L	2089	6/9/2003	0.01	4.39	0.1	4.49	7.7	1	Ammonia<0.02, TKN<0.2
16444-L	2089	9/24/2003	0.05	7.45	0.1	7.55	10	1	TKN<0.2
16444-L	2089	1/26/2004							
16444-	2089	7/12/2004	0.01	10	0.1	10.1	14	1	ammonia<0.02, TKN<0.2

L									
51309-N	2092	5/29/2001	0.01	0.6			5.2		Well development; NH4 <0.02; No result reported for TKN.
51309-N	2092	2/19/2002	0	0.6	0.1	0.7	6	1	TKN <0.2
51309-N	2092	5/13/2002	0.01	0.51	0.3	0.81	6.5	1	Ammonia <0.02
51309-N	2092	6/17/2002							
51309-N	2092	7/22/2002							
51309-N	2092	8/19/2002	0.01	0.42	0.1	0.52	7	1	TKN <0.2, ammonia <0.02
51309-N	2092	9/16/2002							
51309-N	2092	10/14/2002							
51309-N	2092	11/4/2002	0.01	0.34	0.1	0.44	7.1	1	Ammonia <0.02, TKN <0.2
51309-N	2092	2/18/2003	0.04	0.228	0.1	0.328	7.3	1	TKN <0.2
51309-N	2092	5/12/2003	0.01	0.192	0.1	0.292	7.6	1	Ammonia <0.02, TKN <0.2
51309-N	2092	8/18/2003	0.01	0.146	0.1	0.246	7.9	1	NH4AsN<0.02, TKN<0.2
51309-N	2092	11/18/2003	0.01	0.165	0.1	0.265	7.5	1	NH4AsN<0.02, TKN<0.2
51309-N	2092	11/18/2003	0.01	0.168	0.1	0.268	7.3	1	QA Duplicate; NH4AsN<0.02, TKN<0.2
51309-N	2092	3/1/2004							
51309-N	2092	6/21/2004							
51309-N	2093	5/29/2001	0.01	1.31			3.5		Well development; NH4 <0.02; No result reported for TKN
51309-N	2093	2/19/2002	0	2.6	0.1	2.7	2.7	1	TKN <0.2
51309-N	2093	5/13/2002	0.01	9.58	0.3	9.88	7.7	1	Ammonia <0.02
51309-N	2093	6/17/2002							
51309-N	2093	7/22/2002							
51309-N	2093	8/19/2002	0.01	5.89	0.1	5.99	4.6	1	TKN <0.2, ammonia <0.02
51309-	2093	9/16/2002							

N									
51309-N	2093	10/14/2002							
51309-N	2093	11/4/2002	0.05	2.78	0.1	2.88	3	1	TKN <0.2
51309-N	2093	2/18/2003	0.03	2.51	0.2	2.71	3.4	1	
51309-N	2093	5/12/2003	0.01	4.28	0.1	4.38	3.8	1	Ammonia <0.02, TKN <0.2
51309-N	2093	8/18/2003	0.01	2.09	0.1	2.19	2.9	1	NH4AsN<0.02, TKN<0.2
51309-N	2093	11/18/2003	0.01	1.61	0.1	1.71	2.6	1	NH4AsN<0.02, TKN<0.2
51309-N	2093	3/1/2004							
51309-N	2093	6/21/2004							
51309-N	2094	5/29/2001	0.04	4.74			8.4		Well development; No result reported for TKN
51309-N	2094	2/19/2002	0	1.1	0.1	1.2	3	1	TKN <0.2; D.O. <0.1
51309-N	2094	5/13/2002	0.01	1.68	0.1	1.78	4.1	1	TKN <0.2, ammonia <0.02
51309-N	2094	6/17/2002							
51309-N	2094	7/22/2002							
51309-N	2094	8/19/2002	0.01	2.13	0.1	2.23	4.4	1	TKN <0.2, ammonia <0.02
51309-N	2094	9/16/2002							
51309-N	2094	10/14/2002							
51309-N	2094	11/4/2002	0.02	3.81	0.2	4.01	5.9	1	
51309-N	2094	2/18/2003	0.06	3.53	0.1	3.63	5.4	1	TKN <0.2
51309-N	2094	5/12/2003	0.01	4.39	0.1	4.49	5.5	1	Ammonia <0.02, TKN <0.2
51309-N	2094	8/18/2003	0.01	4.45	0.1	4.55	5.8	1	NH4AsN<0.02, TKN<0.2
51309-N	2094	11/18/2003	0.01	6.67	0.1	6.77	7.5	1	NH4AsN<0.02, TKN<0.2
51309-N	2094	3/1/2004							
51309-	2094	6/21/2004							

N									
56103-B	2102	5/30/2001	0.03	9.19			11		Background/well development; No result reported for TKN
56103-B	2102	2/12/2002	0	2.3	0.1	2.4	3.9	1	TKN <0.2
56103-B	2102	5/7/2002	0.01	6.1	0.1	6.2	11	1	Ammonia <0.02; TKN <0.2
56103-B	2102	6/11/2002							
56103-B	2102	7/16/2002							
56103-B	2102	8/13/2002	0.01	3.4	0.1	3.5	4.6	1	TKN <0.2 est., ammonia <0.02
56103-B	2102	9/10/2002							
56103-B	2102	10/7/2002							
56103-B	2102	11/6/2002	0.01	4.24	0.1	4.34	3.6	1	Ammonia <0.02, TKN <0.2
56103-B	2102	2/10/2003	0.01	1.43	0.3	1.73	4.7	1	NH4AsN <0.02
56103-B	2102	5/6/2003	0.01	9.55	0.1	9.65	15	1	Ammonia <0.02, TKN <0.2
56103-B	2102	8/12/2003	0.01	4.19	0.1	4.29	11	1	Ammonia<0.02, TKN<0.2
56103-B	2102	11/19/2003	0.01	3.99	0.1	4.09	9.5	1	Ammonia<0.02, TKN<0.2
56103-B	2102	3/29/2004							
56103-B	2102	5/24/2004							
56103-B	2103	5/30/2001	0.03	2.63			2.3		Background/well development; No result reported for TKN
56103-B	2103	2/12/2002	0	2.4	0.1	2.5	3.1	1	TKN <0.2
56103-B	2103	5/7/2002	0.01	1.68	0.1	1.78	3.8	1	Ammonia <0.02; TKN <0.2
56103-B	2103	6/11/2002							
56103-B	2103	7/16/2002							
56103-B	2103	8/13/2002	0.01	1.08	0.1	1.18	4.9	1	TKN <0.2 est., ammonia <0.02
56103-B	2103	9/10/2002							
56103-	2103	10/7/2002							

B									
56103-B	2103	11/6/2002	0.02	2.91	0.1	3.01	6	1	TKN <0.2
56103-B	2103	2/10/2003	0.01	3.42	0.3	3.72	6.9	1	NH4AsN <0.02
56103-B	2103	5/6/2003	0.01	2.52	0.1	2.62	5.9	1	Ammonia <0.02, TKN <0.2
56103-B	2103	8/12/2003	0.02	2.28	0.1	2.38	8.3	1	TKN<0.2
56103-B	2103	11/19/2003	0.01	1.19	0.1	1.29	10	1	Ammonia<0.02, TKN<0.2
56103-B	2103	3/29/2004							
56103-B	2103	5/24/2004							
56103-B	2104	5/30/2001	0.02	1.8			2.2		Background/well development; No result reported for TKN
56103-B	2104	2/12/2002	0	1.9	0.1	2	4.2	1	TKN <0.2
56103-B	2104	5/6/2002	0.01	1.38	0.1	1.48	2.1	1	Ammonia <0.02, TKN <0.2
56103-B	2104	7/16/2002							
56103-B	2104	8/13/2002	0.01	5.15	0.1	5.25	2.4	1	TKN <0.2 est., ammonia <0.02
56103-B	2104	9/10/2002							
56103-B	2104	10/7/2002							
56103-B	2104	11/6/2002	0.03	2.11	0.1	2.21	3.6	1	TKN <0.2
56103-B	2104	2/10/2003	0.01	5.81	0.1	5.91	4.8	1	NH4AsN <0.02, TKN <0.2
56103-B	2104	5/6/2003	0.01	4.63	0.1	4.73	3.9	1	Ammonia <0.02, TKN <0.2
56103-B	2104	8/12/2003	0.01	7.51	0.1	7.61	9.1	1	Ammonia<0.02, TKN<0.2
56103-B	2104	11/19/2003	0.02	1.32	0.1	1.42	5.9	1	TKN<0.2
56103-B	2104	3/29/2004							
56103-B	2104	5/24/2004							
17276-C	2107	5/30/2001	0.02	0.06			2.7		Background/well development, No result reported for TKN
17276-	2107	2/4/2002	0	0.1	0.1	0.2	4.8	1	TKN <0.2

C									
17276-C	2107	5/14/2002	0.01	0.33	0.1	0.43	18	1	TKN <0.2, ammonia <0.02
17276-C	2107	6/25/2002							
17276-C	2107	7/22/2002							
17276-C	2107	8/21/2002	0.01	0.13	0.1	0.23	26	1	TKN <0.2, ammonia <0.02
17276-C	2107	9/17/2002							
17276-C	2107	10/1/2002							
17276-C	2107	10/29/2002	0.01	0.08	0.1	0.18	14	1	Ammonia <0.02, TKN <0.2
17276-C	2107	12/9/2002							
17276-C	2107	2/19/2003	0.04	0.185	0.1	0.285	9.3	1	TKN <0.2
17276-C	2107	5/12/2003	0.01	0.367	0.1	0.467	15	1	Ammonia <0.02, TKN <0.2
17276-C	2107	8/19/2003	0.02	0.439	0.1	0.539	30	1	TKN<0.2
17276-C	2107	11/12/2003	0.01	0.532	0.1	0.632	40	1	Ammonia<0.02, TKN<0.2
17276-C	2107	6/7/2004							
52356-A	2109	9/28/2001	0.01	2.38			11		
52356-A	2109	8/28/2002							
52356-A	2109	9/24/2002							
52356-A	2109	10/23/2002	0.01	1.8	0.1	1.9	13		
52356-A	2109	11/13/2002							
52356-A	2109	12/3/2002							
52356-A	2109	1/14/2003	0.03	1.17	0.2	1.37	13		
52356-A	2109	2/24/2003							
52356-A	2109	3/3/2003							
52356-	2109	4/21/2003	0.01	1.61	0.1	1.71	12		

A							
52356-A	2109	6/16/2003					
52356-A	2109	7/28/2003	0.01	1.26	0.1	1.36	13
52356-A	2109	10/20/2003	0.01	1.44	0.1	1.54	13
52356-A	2110	9/28/2001	0.03	2.16			13
52356-A	2110	8/28/2002					
52356-A	2110	9/24/2002					
52356-A	2110	10/23/2002	0.01	2.83	0.1	2.93	13
52356-A	2110	11/13/2002					
52356-A	2110	12/3/2002					
52356-A	2110	1/14/2003	0.02	2.55	0.1	2.65	13
52356-A	2110	2/24/2003					
52356-A	2110	3/3/2003					
52356-A	2110	4/21/2003	0.01	1.63	0.1	1.73	10
52356-A	2110	6/16/2003					
52356-A	2110	7/28/2003	0.01	1.92	0.2	2.12	12
52356-A	2110	10/20/2003	0.01	1.86	0.1	1.96	12
52356-A	2111	9/28/2001	0.02	3.28			9.6
52356-A	2111	8/28/2002					
52356-A	2111	9/24/2002					
52356-A	2111	10/23/2002	0.01	2.26	0.1	2.36	9.4
52356-A	2111	11/13/2002					
52356-A	2111	12/3/2002					
52356-	2111	1/14/2003	0.06	1.6	0.1	1.7	9.2

A									
52356-A	2111	2/24/2003							
52356-A	2111	3/3/2003							
52356-A	2111	4/21/2003	0.01	1.9	0.1	2	8.4		
52356-A	2111	6/16/2003							
52356-A	2111	7/28/2003	0.01	2.12	0.1	2.22	8.5		
52356-A	2111	10/20/2003	0.01	1.76	0.1	1.86	8.3		
16211-B	2113	10/5/2001	0.03	0			3.2		Background/well development; No result reported for TKN; Nitrate <0.005
16211-B	2113	10/5/2001	0.03	0.0025		0.0025	3.3		QA Duplicate; Well development; No TKN result reported; Nitrate <0.005
16211-B	2113	9/3/2002							
16211-B	2113	9/30/2002	0.1	0.02	0.1	0.12	3.4	1	TKN <0.2
16211-B	2113	10/28/2002							
16211-B	2113	11/19/2002							
16211-B	2113	1/7/2003	0.05	0.0025	0.1	0.1025	3.6	1	Nitrate<0.0050, TKN<0.2
16211-B	2113	2/3/2003							
16211-B	2113	3/3/2003							
16211-B	2113	3/31/2003	0.05	0.0262	0.1	0.1262	3.3	1	TKN <0.2
16211-B	2113	6/23/2003							
16211-B	2113	7/7/2003	0.09	0.0118	0.1	0.1118	4.2	1	TKN<0.2,D.O.<0.1
16211-B	2113	8/19/2003							
16211-B	2113	9/29/2003	0.07	0.0157	0.1	0.1157	4.5	1	TKN<0.2, D.O.<0.1
16211-B	2113	2/9/2004							
16211-B	2114	10/5/2001	0.04	0.0025			7.7		Background/well development; No TKN result reported; Nitrate <0.005
16211-	2114	9/3/2002							

B									
16211-B	2114	9/30/2002	0.04	0.02	0.1	0.12	7.5	1	D.O. <0.1; TKN <0.2
16211-B	2114	10/28/2002							
16211-B	2114	11/19/2002							
16211-B	2114	1/7/2003	0.03	0.0025	0.1	0.1025	8.4	1	Nitrate<0.0050, TKN<0.2
16211-B	2114	2/3/2003							
16211-B	2114	3/3/2003							
16211-B	2114	3/31/2003	0.03	0.0236	0.1	0.1236	8.5	1	TKN <0.2, D.O. <0.1
16211-B	2114	6/23/2003							
16211-B	2114	7/7/2003	0.04	0.0224	0.1	0.1224	8.6	1	TKN<0.2
16211-B	2114	8/19/2003							
16211-B	2114	9/29/2003	0.04	0.0165	0.1	0.1165	7.9	1	TKN<0.2, D.O.<0.1
16211-B	2114	2/9/2004							
16211-B	2115	10/5/2001	0.04	0.0025			2.1		Background/well development; No TKN result reported; Nitrate <0.005
16211-B	2115	9/3/2002							
16211-B	2115	9/30/2002	0.07	0.02	0.1	0.12	3.4	1	TKN < 0.2
16211-B	2115	10/28/2002							
16211-B	2115	11/19/2002							
16211-B	2115	1/7/2003	0.06	0.0025	0.1	0.1025	3.3	1	Nitrate<0.0050, TKN<0.2
16211-B	2115	2/3/2003							
16211-B	2115	3/3/2003							
16211-B	2115	3/31/2003	0.04	0.0769	0.1	0.1769	3.6	1	TKN <0.2
16211-B	2115	6/23/2003							
16211-	2115	7/7/2003	0.05	0.0196	0.1	0.1196	3.5	1	TKN<0.2; Bubbly flow

B									
16211-B	2115	8/19/2003							
16211-B	2115	9/29/2003	0.04	0.0204	0.1	0.1204	3.6	1	TKN<0.2
16211-B	2115	2/9/2004							
51475-D	2117	10/4/2001	0.01	0.23			3.5		Background/well development; No result reported for TKN; NH4 <0.02
51475-D	2117	11/27/2001	0	0.17	0.1	0.27	3.4	1	TKN <0.2
51475-D	2117	2/13/2002	0	0.2	0.1	0.3	3.4	1	TKN <0.2
51475-D	2117	5/6/2002	0.01	0.13	0.1	0.23	3.2	1	Ammonia <0.02, TKN <0.2
51475-D	2117	5/10/2002							
51475-D	2117	6/10/2002							
51475-D	2117	7/15/2002							
51475-D	2117	8/19/2002	0.01	0.13	0.1	0.23	2.6	1	TKN <0.2, ammonia <0.02
51475-D	2117	9/16/2002							
51475-D	2117	10/30/2002	0.01	0.1	0.1	0.2	2.8	1	Ammonia <0.02, TKN <0.2
51475-D	2117	2/18/2003	0.03	0.0808	0.1	0.1808	3.1	1	TKN <0.2
51475-D	2117	5/12/2003	0.01	0.0798	0.1	0.1798	3	1	Ammonia <0.02, TKN <0.2
51475-D	2117	8/18/2003	0.01	0.0709	0.1	0.1709	4.2	1	NH4AsN<0.02, TKN<0.2
51475-D	2117	10/27/2003	0.01	0.131	0.1	0.231	7	1	NH4AsN<0.02, TKN<0.2
51475-D	2117	6/7/2004							
51475-D	2118	10/4/2001	0.08	0.01			2		Background/well development; No result reported for TKN; DO<0.1
51475-D	2118	11/27/2001	0.09	0.0025	0.1	0.1025		1	nitrate <0.005; TKN <0.2
51475-D	2118	2/13/2002	0.1	0	0.2	0.2	1.7	1	D.O. <0.1
51475-D	2118	5/6/2002	0.06	0.01	0.1	0.11	1.8	1	TKN <0.2, D.O. <0.1
51475-	2118	5/10/2002							

D									
51475-D	2118	6/10/2002							
51475-D	2118	7/15/2002							
51475-D	2118	8/19/2002	0.07	0.02	0.1	0.12	1.8	1	TKN <0.2
51475-D	2118	9/16/2002							
51475-D	2118	10/30/2002	0.07	0.01	0.1	0.11	2.2	1	TKN <0.2
51475-D	2118	2/18/2003	0.13	0.00025	0.1	0.1003	2	1	Nitrate-Nitrite <0.0050, TKN <0.2
51475-D	2118	5/12/2003	0.12	0.0025	0.1	0.1025	1.9	1	Nitrate <0.005, TKN <0.2, D.O. <0.1
51475-D	2118	8/18/2003	0.08	0.0025	0.1	0.1025	2.1	1	Nitrate<0.005, TKN<0.2, D.O.<0.1
51475-D	2118	10/27/2003	0.07	0.0025	0.1	0.1025	2.2	1	Nitrate <0.050, TKN<0.2
51475-D	2118	6/7/2004							
51475-D	2119	10/4/2001	0.01	0.16			1.9		Background/well development; NH4<0.02; No result reported for TKN
51475-D	2119	10/4/2001	0.01	0.16			1.9		QA Duplicate; NH4 <0.02; No result reported for TKN
51475-D	2119	11/27/2001	0	0.2	0.1	0.3	1.6	1	TKN <0.2
51475-D	2119	2/13/2002	0	0.13	0.2	0.33	2	1	
51475-D	2119	5/6/2002	0.01	0.15	0.1	0.25	2.1	1	Ammonia <0.02, , TKN <0.2
51475-D	2119	5/10/2002							
51475-D	2119	6/10/2002							
51475-D	2119	7/15/2002							
51475-D	2119	8/19/2002	0.01	0.26	0.1	0.36	1.7	1	TKN <0.2, ammonia <0.02
51475-D	2119	9/16/2002							
51475-D	2119	10/30/2002	0.01	0.27	0.1	0.37	1.9	1	Ammonia <0.02, TKN <0.2
51475-D	2119	2/18/2003	0.05	0.16	0.1	0.26	1.9	1	TKN <0.2
51475-	2119	5/12/2003	0.01	0.198	0.1	0.298	3.1	1	Ammonia <0.02, TKN <0.2

D									
51475-D	2119	8/18/2003	0.01	0.258	0.1	0.358	1.8	1	NH4AsN<0.02, TKN<0.2
51475-D	2119	10/27/2003	0.01	0.304	0.1	0.404	1.9	1	NH4AsN<0.02, TKN<0.2
51475-D	2119	6/7/2004							
15766-K	2121	9/28/2001	0.01	9.84			150		Background/well development; NH4 <0.02; No result reported for TKN
15766-K	2121	9/28/2001	0.01	9.85			150		QA Duplicate; NH4<0.02; No result reported for TKN; Well Development
15766-K	2121	7/15/2002	0.01	13.6	0.3	13.9	160	1	NH4 <0.02
15766-K	2121	8/6/2002							
15766-K	2121	9/9/2002							
15766-K	2121	10/7/2002	0.01	11.3	0.4	11.7	49	1	ammonia < 0.2
15766-K	2121	11/4/2002							
15766-K	2121	12/3/2002							
15766-K	2121	1/21/2003	0.01	3.46	0.1	3.56	57	1	Ammonia <0.02, TKN <0.2
15766-K	2121	2/11/2003							
15766-K	2121	3/10/2003							
15766-K	2121	4/21/2003	0.01	0.576	0.1	0.676	24	1	Ammonia <0.02, TKN <0.2
15766-K	2121	6/17/2003							
15766-K	2121	7/14/2003	0.02	0.428	0.1	0.528	23	1	TKN<0.2
15766-K	2121	10/7/2003	0.02	0.875	0.1	0.975	26	1	TKN<0.2
15766-K	2121	2/9/2004							
15766-K	2121	5/17/2004							
15766-K	2122	9/28/2001							Background/well development; Unable to establish flow to obtain samples
15766-K	2122	10/24/2001	0.06	0.04			1.3		Background/well development; slow, intermittent flow; No TKN result repor
15766-	2122	7/15/2002	0.01	0.1	0.1	0.2	4		TKN <0.2, N<0.02

K									
15766-K	2122	7/24/2002						2	
15766-K	2122	8/6/2002							
15766-K	2122	9/9/2002							DRY - Water Depth >19.32
15766-K	2122	10/7/2002							DRY - water level >18.96
15766-K	2122	11/4/2002							depth >19.32
15766-K	2122	12/3/2002							
15766-K	2122	1/21/2003							Dry; Depth >19.31
15766-K	2122	2/11/2003							depth >19.32
15766-K	2122	3/10/2003							depth >19.34
15766-K	2122	4/21/2003							Dry to well screen: depth >19.27 - No samples.
15766-K	2122	6/17/2003							depth >19.34'
15766-K	2122	7/14/2003							Dry; depth >19.26
15766-K	2122	10/7/2003							DRY, depth >19.26, all tests cancelled
15766-K	2122	2/9/2004							DRY; depth to water >19.26
15766-K	2122	5/17/2004							depth to water>19.24
56083-M	2124	9/27/2001	0.08	1.05	0	1.05	25		Background/well development; No result reported for TKN
56083-M	2124	2/12/2002	0.06	0.8	0.2	1	11	1	
56083-M	2124	5/7/2002	0.02	0.5	0.3	0.8	6.7	1	
56083-M	2124	6/11/2002							
56083-M	2124	7/16/2002							
56083-M	2124	8/13/2002	0.03	1.09	0.1	1.19	7.4	1	TKN <0.2 est.
56083-M	2124	9/10/2002							
56083-	2124	10/7/2002							

M									
56083-M	2124	11/6/2002	0.02	2.04	0.1	2.14	8.8	1	TKN <0.2
56083-M	2124	2/10/2003	0.02	5.15	0.1	5.25	9.9	1	TKN <0.2
56083-M	2124	5/6/2003	0.01	3.72	0.1	3.82	12	1	Ammonia <0.02, TKN <0.2
56083-M	2124	8/12/2003	0.01	1.62	0.1	1.72	18	1	Ammonia<0.02, TKN<0.2
56083-M	2124	10/29/2003	0.01	5.86	0.1	5.96	20	1	NH4AsN<0.02, TKN<0.2
56083-M	2124	5/24/2004							
56083-M	2125	9/27/2001	0.05	1.97	0	1.97	3.6		Background/well development; No result reported for TKN
56083-M	2125	2/12/2002	0	3.82	0.1	3.92	7.3	1	TKN <0.2
56083-M	2125	5/7/2002	0.01	4.43	0.1	4.53	8.8	1	Ammonia <0.02; TKN <0.2
56083-M	2125	6/11/2002							
56083-M	2125	7/16/2002							
56083-M	2125	8/13/2002	0.01	4.05	0.1	4.15	7.2	1	TKN <0.2 est., ammonia <0.02
56083-M	2125	9/10/2002							
56083-M	2125	10/7/2002							
56083-M	2125	11/6/2002	0.01	3.67	0.1	3.77	7.8	1	Ammonia <0.02, TKN <0.2
56083-M	2125	2/10/2003	0.02	3.08	0.1	3.18	9.6	1	TKN <0.2
56083-M	2125	5/6/2003	0.01	1.61	0.6	2.21	13	1	Ammonia <0.02
56083-M	2125	8/12/2003	0.01	0.836	0.1	0.936	12	1	Ammonia<0.02, TKN<0.2
56083-M	2125	10/29/2003	0.01	0.676	0.1	0.776	11	1	NH4AsN<0.02, TKN<0.2
56083-M	2125	5/24/2004							
51468-P	2127	10/10/2001	0.03	7.16			13		
51468-P	2127	7/29/2002	0.01	7.68	0.2	7.88	13		
51468-	2127	8/27/2002							

P							
51468-P	2127	9/16/2002					
51468-P	2127	10/14/2002	0.02	8.45	0.2	8.65	12
51468-P	2127	11/4/2002					
51468-P	2127	12/9/2002					
51468-P	2127	1/14/2003	0.01	8.22	0.1	8.32	13
51468-P	2127	2/11/2003					
51468-P	2127	4/21/2003	0.01	7.45	0.1	7.55	9.6
51468-P	2127	6/23/2003					
51468-P	2127	7/21/2003	0.01	6.37	0.3	6.67	7.9
51468-P	2127	10/15/2003	0.01	9.42	0.1	9.52	9.4
51468-P	2127	3/1/2004					
51468-P	2128	10/10/2001	0.01	4.15			7.2
51468-P	2128	7/29/2002	0.01	5.95	0.1	6.05	10
51468-P	2128	8/27/2002					
51468-P	2128	9/16/2002					
51468-P	2128	10/14/2002	0.02	4.92	0.1	5.02	11
51468-P	2128	11/4/2002					
51468-P	2128	12/9/2002					
51468-P	2128	1/14/2003	0.01	4.45	0.1	4.55	7.5
51468-P	2128	2/11/2003					
51468-P	2128	4/21/2003	0.01	4.4	0.2	4.6	6.7
51468-P	2128	6/23/2003					
51468-	2128	7/21/2003	0.01	3.88	0.1	3.98	7.5

P									
51468-P	2128	10/15/2003	0.01	2.62	0.1	2.72	8.5		
51468-P	2128	3/1/2004							
51468-P	2129	10/10/2001	0.03	0.35			5.4		
51468-P	2129	7/29/2002	0.01	4.32	0.1	4.42	11		
51468-P	2129	8/27/2002							
51468-P	2129	9/16/2002							
51468-P	2129	10/14/2002	0.01	3.76	0.3	4.06	9.2		
51468-P	2129	11/4/2002							
51468-P	2129	12/9/2002							
51468-P	2129	1/14/2003	0.03	3.02	0.1	3.12	8.5		
51468-P	2129	2/11/2003							
51468-P	2129	4/21/2003	0.01	2.71	0.1	2.81	8		
51468-P	2129	6/23/2003							
51468-P	2129	7/21/2003	0.03	1.96	0.1	2.06	7.4		
51468-P	2129	10/15/2003	0.01	3.48	0.1	3.58	11		
51468-P	2129	3/1/2004							
55730-P	2135	9/21/2001	0.01	0.04	0.1	0.14	1.1		NH4 <0.02; TKN <0.2
55730-P	2135	9/21/2001	0.01	0.04	0.3	0.34	1		QA Duplicate; NH4 <0.02
55730-P	2135	10/30/2002							
55730-P	2135	11/19/2002							
55730-P	2135	1/7/2003	0.05	0.0408	0.1	0.1408	0.9	1	TKN<0.2
55730-P	2135	2/4/2003							
55730-	2135	3/4/2003							

P									
55730-P	2135	3/31/2003	0.01	0.111	0.1	0.211	0.8	1	Ammonia <0.02, TKN <0.2
55730-P	2135	6/11/2003							
55730-P	2135	7/15/2003	0.01	0.203	0.2	0.403	0.8	1	Ammonia<0.02
55730-P	2135	8/19/2003							
55730-P	2135	10/7/2003	0.01	0.15	0.1	0.25	0.9	1	NH4AsN<0.02, TKN<0.2
55730-P	2135	2/4/2004							
55730-P	2135	5/17/2004							
55730-P	2136	10/24/2001	0.04	0.02			0.9		Background/well development; slow, intermittent flow; No TKN result repor
55730-P	2136	10/30/2002							
55730-P	2136	11/19/2002							
55730-P	2136	1/7/2003	0.03	0.0112	0.1	0.1112	1.2	1	TKN<0.2
55730-P	2136	2/4/2003							
55730-P	2136	3/4/2003							
55730-P	2136	3/31/2003	0.04	0.0386	0.1	0.1386			Field Tests "NR", TKN <0.2
55730-P	2136	6/11/2003							
55730-P	2136	7/15/2003	0.05	0.0122	0.1	0.1122	10	1	Extreme slow flow; not enough sample volume to check field parameters; <0.2
55730-P	2136	8/19/2003							
55730-P	2136	10/6/2003	0.05	0.0292	0.3	0.3292	8.5		
55730-P	2136	2/4/2004							
55730-P	2136	5/17/2004							
51451-F	2146	1/3/2002	0.01	0.05			6		Background/well development; No TKN result reported; NH4 <0.02.
51451-F	2146	2/11/2002	0	0	0.1	0.1	6	1	TKN <.2
51451-	2146	5/13/2002	0.04	0.07	0.1	0.17	6.5		TKN <0.2

F									
51451-F	2146	6/17/2002							
51451-F	2146	7/22/2002							
51451-F	2146	8/19/2002	0.01	0.06	0.1	0.16	6.5	1	TKN <0.2, ammonia <0.02
51451-F	2146	9/16/2002							
51451-F	2146	10/14/2002							
51451-F	2146	11/4/2002	0.01	0.04	0.1	0.14	6.9	1	Ammonia <0.02, TKN <0.2
51451-F	2146	2/18/2003	0.04	0.0367	0.7	0.7367	7.1	1	
51451-F	2146	5/20/2003	0.01	0.0609	0.1	0.1609	7.5	1	NH4<0.02, TKN<0.2
51451-F	2146	8/18/2003	0.02	0.0623	0.1	0.1623	7.6	1	TKN<0.2
51451-F	2146	11/18/2003	0.01	0.0333	0.1	0.1333	7.5	1	NH4AsN<0.02, TKN<0.2
51451-F	2146	3/1/2004							
51451-F	2146	6/21/2004							
51451-F	2147	1/3/2002	0.21	0.01			5.1		Background/well development; No TKN result reported; Nitrate is estimate
51451-F	2147	2/11/2002	0.2	0	0.2	0.2	4.9	1	
51451-F	2147	5/13/2002	0.21	0	0.3	0.3	5.4	1	Nitrate/nitrite <0.005
51451-F	2147	6/17/2002							
51451-F	2147	7/22/2002							
51451-F	2147	8/19/2002	0.18	0.01	0.3	0.31	5.2	1	D.O. <0.1
51451-F	2147	9/16/2002							
51451-F	2147	10/14/2002							
51451-F	2147	11/4/2002	0.21	0.01	0.1	0.11	5.6	1	TKN <0.2, D.O. <0.1
51451-F	2147	2/18/2003	0.27	0.00025	0.3	0.3003	5.6	1	Nitrate-Nitrite <0.0050
51451-	2147	5/20/2003	0.2	0.0061	0.1	0.1061	5.4	1	TKN<0.2

F									
51451-F	2147	8/18/2003	0.02	0.0025	0.3	0.3025	6.3	1	Nitrate<0.005, D.O.<0.1
51451-F	2147	11/18/2003	0.19	0.0025	0.1	0.1025	5.3	1	Nitrate <0.050, TKN<0.2
51451-F	2147	3/1/2004							
51451-F	2147	6/21/2004							
51451-F	2148	1/3/2002	0.04	0.9			68		Background/well development; No TKN result reported.
51451-F	2148	2/11/2002	0	1.4	0.2	1.6	75	1	
51451-F	2148	5/13/2002	0.01	1.83	0.1	1.93	100	1	TKN <0.2, ammonia <0.02
51451-F	2148	6/17/2002							
51451-F	2148	7/22/2002							
51451-F	2148	8/19/2002	0.01	1.1	0.1	1.2	85	1	TKN <0.2, ammonia <0.02
51451-F	2148	9/16/2002							
51451-F	2148	10/14/2002							
51451-F	2148	11/4/2002	0.02	0.68	0.1	0.78	55	1	TKN <0.2
51451-F	2148	2/18/2003	0.05	1	0.1	1.1	86	1	TKN <0.2
51451-F	2148	5/20/2003	0.01	0.832	0.1	0.932	71	1	NH4<0.02, TKN<0.2
51451-F	2148	8/18/2003	0.01	0.909	0.2	1.109	76	1	NH4AsN<0.02
51451-F	2148	11/18/2003	0.01	0.709	0.1	0.809	63	1	NH4AsN<0.02, TKN<0.2
51451-F	2148	3/1/2004							
51451-F	2148	6/21/2004							
15910-E	2154	1/4/2002	0.21	0.01		0.01	1.9		Well development; No TKN result reported; DO <1.0
15910-E	2154	2/25/2002	0.2	0	0.2	0.2	2	1	
15910-E	2154	5/20/2002	0.2	0.01	0.3	0.31	2.3	1	
15910-	2154	6/25/2002							

E									
15910-E	2154	7/29/2002							
15910-E	2154	8/26/2002	0.18	0.01	0.3	0.31	2	1	
15910-E	2154	9/25/2002							
15910-E	2154	10/23/2002							
15910-E	2154	11/12/2002	0.2	0.0025	0.3	0.3025	1.9	1	Nitrate/nitrite <0.0050
15910-E	2154	2/24/2003	0.24	0.0169	0.2	0.2169	2	1	
15910-E	2154	5/5/2003	0.18	0.0025	0.1	0.1025	2.6	1	Nitrate <0.005, TKN <0.2
15910-E	2154	8/26/2003	0.18	0.0025	0.2	0.2025	2.3	1	Nitrate<0.005
15910-E	2154	11/12/2003	0.18	0.0025	0.1	0.1025	2.4	1	Nitrate<0.005, TKN<0.2
15910-E	2154	6/7/2004							
15910-E	2155	1/4/2002	0.56	0.01			28		Background/well development; No TKN result reported.
15910-E	2155	2/25/2002	0.5	0	0.6	0.6	23	1	
15910-E	2155	5/20/2002	0.48	0.01	0.6	0.61	19	1	QA duplicate
15910-E	2155	5/20/2002	0.46	0.01	0.6	0.61	18	1	
15910-E	2155	6/25/2002							
15910-E	2155	7/29/2002							
15910-E	2155	8/26/2002	0.47	0.01	0.6	0.61	26	1	
15910-E	2155	9/25/2002							
15910-E	2155	10/23/2002							
15910-E	2155	11/12/2002	0.48	0.0053	0.5	0.5053	26	1	
15910-E	2155	2/24/2003	0.48	0.0225	0.5	0.5225	20	1	
15910-E	2155	5/5/2003	0.45	0.0067	0.5	0.5067	18	1	
15910-	2155	8/26/2003	0.44	0.0025	0.5	0.5025	15	1	Nitrate<0.005

E									
15910-E	2155	11/12/2003	0.43	0.0025	0.4	0.4025	13	1	Nitrate<0.005
15910-E	2155	6/7/2004							
15910-E	2156	1/4/2002	0.01	0.01			2.8		Background/well development; No TKN result reported; NH4 <0.02.
15910-E	2156	2/25/2002	0	0	0.1	0.1	3.1	1	TKN <0.2
15910-E	2156	5/20/2002	0.01	0.01	0.1	0.11	3.4	1	TKN <0.2, ammonia <0.02
15910-E	2156	6/25/2002							
15910-E	2156	7/29/2002							
15910-E	2156	8/26/2002	0.01	0.02	0.1	0.12	3.7	1	TKN <0.2, ammonia <0.02
15910-E	2156	9/25/2002							
15910-E	2156	10/23/2002							
15910-E	2156	11/12/2002	0.04	0.0259	0.1	0.1259	4.9	1	TKN <0.2
15910-E	2156	2/24/2003	0.03	0.0638	0.1	0.1638	4.1	1	TKN <0.2
15910-E	2156	5/5/2003	0.01	0.0658	0.1	0.1658	4	1	Ammonia <0.02, TKN <0.2
15910-E	2156	8/26/2003	0.01	0.0619	0.1	0.1619	4	1	NH4AsN<0.02, TKN<0.2
15910-E	2156	11/12/2003	0.01	0.0666	0.1	0.1666	4.1	1	Ammonia<0.02, TKN<0.2
15910-E	2156	6/7/2004							
52631-A	2158	1/3/2002	0.02	2.31			8.8		
52631-A	2158	8/12/2002							
52631-A	2158	10/8/2002	0.02	2.8	0.1	2.9	8.4		
52631-A	2158	11/5/2002							
52631-A	2158	12/3/2002							
52631-A	2158	1/14/2003	0.01	2.94	0.2	3.14	9		
52631-	2158	2/18/2003							

A							
52631-A	2158	3/3/2003					
52631-A	2158	4/21/2003	0.01	3.07	0.1	3.17	9.1
52631-A	2158	6/16/2003					
52631-A	2158	7/28/2003	0.01	3.72	2	5.72	12
52631-A	2158	10/7/2003	0.01	4.4	0.1	4.5	13
52631-A	2158	2/4/2004					
52631-A	2158	7/12/2004					
52631-A	2159	1/3/2002	0.01	3.3			8.2
52631-A	2159	8/12/2002					
52631-A	2159	10/8/2002	0.03	3.93	0.1	4.03	8
52631-A	2159	11/5/2002					
52631-A	2159	12/3/2002					
52631-A	2159	1/14/2003	0.03	3.34	0.1	3.44	8
52631-A	2159	2/18/2003					
52631-A	2159	3/3/2003					
52631-A	2159	4/21/2003	0.01	4.07	0.1	4.17	7.9
52631-A	2159	6/16/2003					
52631-A	2159	7/28/2003	0.01	3.22	0.2	3.42	7.6
52631-A	2159	10/7/2003	0.01	3.02	0.1	3.12	7.1
52631-A	2159	2/4/2004					
52631-A	2159	7/12/2004					
52631-A	2160	1/3/2002	0.31	13.1			18
52631-	2160	8/12/2002					

A							
52631-A	2160	10/8/2002	0.01	7.02	0.1	7.12	15
52631-A	2160	10/15/2002					
52631-A	2160	10/15/2002					
52631-A	2160	10/15/2002					
52631-A	2160	11/5/2002					
52631-A	2160	12/3/2002					
52631-A	2160	1/14/2003	0.02	8.14	0.1	8.24	21
52631-A	2160	2/18/2003					
52631-A	2160	3/3/2003					
52631-A	2160	4/21/2003	0.03	11.7	0.1	11.8	21
52631-A	2160	6/16/2003					
52631-A	2160	7/28/2003	0.01	8.12	0.1	8.22	21
52631-A	2160	10/7/2003	0.01	7.15	0.1	7.25	20
52631-A	2160	2/4/2004					
52631-A	2160	7/12/2004					
16320-J	2162	1/4/2002	0.04	0.01			2.2
16320-J	2162	1/4/2002	0.04	0.01			2
16320-J	2162	9/3/2002					
16320-J	2162	10/1/2002	0.04	0.02	0.1	0.12	1.9
16320-J	2162	10/30/2002					
16320-J	2162	11/19/2002					
16320-J	2162	1/7/2003	0.01	0.0154	0.1	0.1154	2
16320-	2162	2/11/2003					

J							
16320-J	2162	3/3/2003					
16320-J	2162	4/14/2003	0.03	0.0112	0.1	0.1112	2
16320-J	2162	6/9/2003					
16320-J	2162	7/7/2003	0.03	0.0161	0.1	0.1161	2
16320-J	2162	9/29/2003	0.03	0.0186	0.1	0.1186	1.8
16320-J	2162	2/4/2004					
16320-J	2162	5/17/2004					
16320-J	2163	1/4/2002	0.03	0.9			5.3
16320-J	2163	9/3/2002					
16320-J	2163	10/1/2002	0.07	0.83	0.1	0.93	5.6
16320-J	2163	10/30/2002					
16320-J	2163	11/19/2002					
16320-J	2163	1/7/2003					
16320-J	2163	2/11/2003					
16320-J	2163	3/3/2003					
16320-J	2163	4/14/2003	0.02	0.652	0.1	0.752	5.3
16320-J	2163	6/9/2003					
16320-J	2163	7/7/2003	0.02	0.474	0.1	0.574	5.4
16320-J	2163	9/29/2003	0.02	0.754	0.1	0.854	6.9
16320-J	2163	2/4/2004					
16320-J	2163	5/17/2004					
16320-J	2164	1/4/2002	0.18	0.01			4.9
16320-	2164	9/3/2002					

J									
16320-J	2164	10/1/2002	0.17	0.01	0.2	0.21	5.7		
16320-J	2164	10/30/2002							
16320-J	2164	11/19/2002							
16320-J	2164	1/7/2003	0.15	0.0051	0.1	0.1051	2		
16320-J	2164	2/11/2003							
16320-J	2164	3/3/2003							
16320-J	2164	4/14/2003	0.16	0.0025	0.1	0.1025	5.9		
16320-J	2164	6/9/2003							
16320-J	2164	7/7/2003	0.15	0.0092	0.1	0.1092	5.9		
16320-J	2164	9/29/2003	0.17	0.0104	0.1	0.1104	6.2		
16320-J	2164	2/4/2004							
16320-J	2164	5/17/2004							
52922-S	2166	1/3/2002	0.01	2.53			4.1		Background/well development; No TKN result reported; NH4 <0.02.
52922-S	2166	1/3/2002	0.01	2.54			4.1		QA Duplicate; Background/well development; NH4<0.02; No TKN reporte
52922-S	2166	5/1/2002	0.01	1.8	0.1	1.9	3.6	1	Ammonia <0.02; TKN <0.2
52922-S	2166	8/5/2002	0.09	2.3	0.3	2.6	4		
52922-S	2166	8/12/2002						2	Bacteria Re-sample
52922-S	2166	9/4/2002							
52922-S	2166	10/2/2002							
52922-S	2166	10/29/2002							Depth >10.72
52922-S	2166	11/19/2002							Well dry, depth >11.10
52922-S	2166	1/7/2003							
52922-	2166	2/4/2003	0.01	1.34	0.1	1.44	3	2	NH4<0.02, TKN<0.2

S									
52922-S	2166	4/28/2003	0.02	2.02	0.2	2.22	3	1	
52922-S	2166	8/4/2003	0.01	2.49	0.1	2.59	4.8	1	Ammonia<0.02, TKN<0.2
52922-S	2166	10/28/2003							All tests cancelled. Depth >11.04; DRY
52922-S	2166	1/12/2004				199998			
52922-S	2166	3/1/2004							
52922-S	2166	5/24/2004							
52922-S	2167	1/3/2002							Unable to sample - dry to bottom of screen.
52922-S	2168	1/3/2002	0.07	0.06			11		Background/well development; No TKN result reported.
52922-S	2168	5/1/2002	0.02	0.03	0.1	0.13	9.6	1	TKN <0.2
52922-S	2168	8/5/2002	0.04	0.04	0.2	0.24	11	1	
52922-S	2168	9/4/2002							
52922-S	2168	10/2/2002							
52922-S	2168	10/29/2002	0.01	0.03	0.1	0.13	9.7	1	Ammonia <0.02, TKN <0.2
52922-S	2168	11/19/2002							
52922-S	2168	1/7/2003							
52922-S	2168	2/4/2003	0.02	0.0192	0.1	0.1192	8.5	1	TKN<0.2
52922-S	2168	4/28/2003	0.01	0.0552	0.1	0.1552	9.4	1	Ammonia <0.02, TKN <0.2
52922-S	2168	8/4/2003	0.01	0.0616	0.1	0.1616	9.3	1	Ammonia<0.02, TKN<0.2
52922-S	2168	10/28/2003	0.01	0.0974	0.1	0.1974	8.8	1	NH4AsN<0.02, TKN<0.2
52922-S	2168	1/12/2004							
52922-S	2168	3/1/2004							
52922-S	2168	5/24/2004							
52922-	2169	5/1/2002	0.01	0.5	0.1	0.6	4.3	1	Ammonia <0.02; TKN <0.2

S									
52922-S	2169	8/5/2002	0.03	4.18	0.5	4.68	13		
52922-S	2169	9/4/2002							
52922-S	2169	10/2/2002							
52922-S	2169	10/29/2002	0.01	2.44	0.1	2.54	8.5	1	Ammonia <0.02, TKN <0.2
52922-S	2169	11/19/2002							
52922-S	2169	1/7/2003							
52922-S	2169	2/4/2003	0.01	1.31	0.1	1.41	6.6	1	NH4<0.02, TKN<0.2
52922-S	2169	4/28/2003	0.01	2.03	0.2	2.23	10	1	Ammonia <0.02
52922-S	2169	8/4/2003	0.01	2.94	0.1	3.04	9.2	1	Ammonia<0.02, TKN<0.2
52922-S	2169	10/28/2003	0.01	3.06	0.1	3.16	9.4	1	NH4AsN<0.02, TKN<0.2
52922-S	2169	1/12/2004							
52922-S	2169	3/1/2004							
52922-S	2169	5/24/2004							
53387-P	2178	1/2/2002	0.01	0.51			2.7		
53387-P	2178	8/27/2002							
53387-P	2178	9/23/2002							
53387-P	2178	10/22/2002	0.01	0.28	0.1	0.38	2.1		
53387-P	2178	11/13/2002							
53387-P	2178	12/17/2002							
53387-P	2178	1/28/2003	0.01	0.272	0.1	0.372	2		
53387-P	2178	2/19/2003							
53387-P	2178	3/19/2003							
53387-	2178	4/15/2003	0.02	0.367	0.1	0.467	2.2		

P							
53387-P	2178	6/17/2003					
53387-P	2178	7/29/2003	0.01	0.428	0.1	0.528	2.6
53387-P	2178	10/14/2003	0.01	0.236	0.1	0.336	2.6
53387-P	2179	1/2/2002	0.04	1.62			15
53387-P	2179	8/27/2002					
53387-P	2179	9/23/2002					
53387-P	2179	10/22/2002	0.01	1.67	0.4	2.07	8.4
53387-P	2179	11/13/2002					
53387-P	2179	12/17/2002					
53387-P	2179	1/28/2003	0.01	2.14	0.4	2.54	8
53387-P	2179	2/19/2003					
53387-P	2179	3/19/2003					
53387-P	2179	4/15/2003	0.01	3.26	0.1	3.36	8.8
53387-P	2179	6/17/2003					
53387-P	2179	7/29/2003	0.01	2.59	0.1	2.69	7.7
53387-P	2179	10/14/2003	0.07	2.25	0.1	2.35	7.3
53387-P	2180	1/2/2002	0.01	0.63			2.6
53387-P	2180	8/27/2002					
53387-P	2180	9/23/2002					
53387-P	2180	10/22/2002	0.01	0.62	0.1	0.72	2.4
53387-P	2180	11/13/2002					
53387-P	2180	12/17/2002					
53387-	2180	1/28/2003	0.01	0.616	0.1	0.716	2.2

P									
53387-P	2180	2/19/2003							
53387-P	2180	3/19/2003							
53387-P	2180	4/15/2003	0.01	0.613	0.2	0.813	2.5		
53387-P	2180	6/17/2003							
53387-P	2180	7/29/2003	0.01	0.509	0.2	0.709	2.9		
53387-P	2180	10/14/2003	0.01	0.651	0.1	0.751	3.1		
16776-M	2182	11/16/2001	0.41	0.01			3.4		Background/well development; No TKN result reported.
16776-M	2182	2/5/2002	0.4	0	0.5	0.5	2.9	1	
16776-M	2182	4/30/2002	0.41	0	0.5	0.5	3.4	1	D.O. <0.1
16776-M	2182	8/6/2002	0.34	0.01	0.6	0.61	2.9	1	
16776-M	2182	9/3/2002							
16776-M	2182	10/2/2002							
16776-M	2182	10/28/2002	0.45	0.02	0.7	0.72	15	1	
16776-M	2182	11/18/2002							
16776-M	2182	2/3/2003	0.56	0.00025	0.9	0.9003	54	1	Nitrate-Nitrite <0.0050
16776-M	2182	4/29/2003	0.46	0.0025	0.5	0.5025	12	1	Nitrate <0.005
16776-M	2182	8/5/2003	0.37	0.0025	0.4	0.4025	4.7	1	Nitrate<0.0050, D.O.<0.1
16776-M	2182	11/4/2003	0.39	0.0194	0.5	0.5194	4.9	1	
16776-M	2182	3/1/2004							
16776-M	2182	5/24/2004							
16776-M	2183	11/16/2001	0.78	0.01			2		Background/well development; No TKN result reported; D.O. <0.1
16776-M	2183	2/5/2002	0.9	0	1	1	2.1	1	
16776-	2183	4/30/2002	0.83	0	0.9	0.9	1.7	1	D.O. <0.1

M									
16776-M	2183	8/6/2002	0.88	0.01	1.1	1.11	5.5		
16776-M	2183	8/12/2002						2	Bacteria Re-sample
16776-M	2183	9/3/2002							
16776-M	2183	10/2/2002							
16776-M	2183	10/28/2002	1.1	0.02	1.1	1.12	3.4	2	D.O. <0.1
16776-M	2183	11/18/2002							
16776-M	2183	2/3/2003	0.95	0.0051	1.3	1.3051	2.3	2	
16776-M	2183	4/29/2003	0.92	0.0108	1	1.0108	2	1	
16776-M	2183	8/5/2003	0.87	0.0078	1	1.0078	2.6	1	D.O. <0.1
16776-M	2183	11/4/2003	0.93	0.0167	1.1	1.1167	2.5	1	
16776-M	2183	3/1/2004							
16776-M	2183	5/24/2004							
16776-M	2184	11/16/2001	1.3	0.03			14		Background/well development; No TKN result reported
16776-M	2184	2/5/2002	1.9	0	2.1	2.1	15	1	
16776-M	2184	4/30/2002	2	0.17	2.1	2.27	20	1	D.O. <0.1
16776-M	2184	8/6/2002	0.97	0.07	2	2.07	17		D.O. <0.1
16776-M	2184	8/12/2002						2	Bacteria re-sample; D.O. <0.1
16776-M	2184	9/3/2002							
16776-M	2184	10/2/2002							
16776-M	2184	10/28/2002	2	0.02	2	2.02	17	2	
16776-M	2184	11/18/2002							
16776-M	2184	2/3/2003	1.9	0.0268	2.3	2.3268	29	2	D.O. <0.1
16776-	2184	4/29/2003	0.99	0.0367	2	2.0367	20	2	D.O. <0.1

M									
16776-M	2184	8/5/2003	1.9	0.0231	2	2.0231	19	1	D.O. <0.1
16776-M	2184	11/4/2003	1.9	0.0245	2	2.0245	18		
16776-M	2184	11/18/2003						2	Bacteria Re-sample
16776-M	2184	11/18/2003						2	QA Duplicate
16776-M	2184	3/1/2004							
16776-M	2184	5/24/2004							
17365-T	2190	12/21/2001	0.03	0.35			1.1		Background/well development; No TKN result reported.
17365-T	2190	2/19/2002	0	0.5	0.5	1	1.1	1	
17365-T	2190	5/14/2002	0.15	0.53	0.1	0.63	1.1	1	TKN <0.2
17365-T	2190	6/19/2002							
17365-T	2190	7/22/2002							
17365-T	2190	8/20/2002	0.01	0.87	0.1	0.97	0.9	1	TKN <0.2, ammonia <0.02
17365-T	2190	9/17/2002							
17365-T	2190	10/14/2002							
17365-T	2190	11/5/2002	0.01	0.95	0.1	1.05	1.3	1	Ammonia <0.02, TKN <0.2
17365-T	2190	12/9/2002							
17365-T	2190	2/11/2003	0.01	1.23	0.2	1.43	1.8	1	NH4AsN <0.02
17365-T	2190	5/6/2003	0.01	1.42	0.1	1.52	1.9	1	Ammonia <0.02, TKN <0.2
17365-T	2190	8/11/2003	0.01	1.58	0.1	1.68	1.9	1	NH4AsN<0.02, TKN<0.2
17365-T	2190	11/4/2003	0.01	1.7	0.1	1.8	2.1	1	NH4AsN<0.02, TKN<0.2
17365-T	2190	6/7/2004							
17365-T	2191	12/21/2001	0.01	4.47			4.7		well development; no TKN result reported; nitrate result is <0.02; NH4 <0.0
17365-	2191	2/19/2002	0	4.2	0.1	4.3	4.4	1	TKN <0.1

T									
17365-T	2191	5/14/2002	0.01	3.87	0.1	3.97	4.4	1	TKN <0.2, ammonia <0.02
17365-T	2191	6/19/2002							
17365-T	2191	7/22/2002							
17365-T	2191	8/20/2002	0.01	4.25	0.1	4.35	4.4	1	TKN <0.2, ammonia <0.02
17365-T	2191	9/17/2002							
17365-T	2191	10/14/2002							
17365-T	2191	11/5/2002	0.03	4.12	0.1	4.22	4.4	1	TKN <0.2
17365-T	2191	12/9/2002							
17365-T	2191	2/11/2003	0.03	3.83	0.1	3.93	4.2	1	TKN <0.2
17365-T	2191	5/6/2003	0.01	3.48	0.1	3.58	3.6	1	Ammonia <0.02, TKN <0.2
17365-T	2191	8/11/2003	0.04	3.21	0.1	3.31	3.6	1	TKN<0.2
17365-T	2191	11/4/2003	0.01	3.3	0.1	3.4	3.5	1	NH4AsN<0.02, TKN<0.2
17365-T	2191	6/7/2004							
17365-T	2192	11/21/2001	0.05	1.14	0.1	1.24	2.8		Background/well development; TKN <0.2
17365-T	2192	2/19/2002	0	1.3	0.3	1.6	2.3	1	
17365-T	2192	5/14/2002	0.01	1.12	0.1	1.22	2.5	1	TKN <0.2, ammonia <0.02
17365-T	2192	6/19/2002							
17365-T	2192	7/22/2002							
17365-T	2192	8/20/2002	0.01	1.2	0.1	1.3	2.1	1	TKN <0.2, ammonia <0.02
17365-T	2192	9/17/2002							
17365-T	2192	10/14/2002							
17365-T	2192	11/5/2002	0.03	1.31	0.1	1.41	2.7	1	TKN <0.2
17365-	2192	12/9/2002							

T									
17365-T	2192	2/11/2003	0.01	1.39	0.1	1.49	2.7	1	NH4AsN <0.02, TKN <0.2
17365-T	2192	5/6/2003	0.01	1.39	0.1	1.49	2.5	1	Ammonia <0.02, TKN <0.2
17365-T	2192	8/11/2003	0.01	1.36	0.1	1.46	2.6	1	NH4AsN<0.02, TKN<0.2
17365-T	2192	11/4/2003	0.01	1.49	0.1	1.59	2.6	1	NH4AsN<0.02, TKN<0.2
17365-T	2192	6/7/2004							
16168-M	2194	1/2/2002	0.03	4.51			9		Well development; No TKN result reported.
16168-M	2194	8/27/2002							
16168-M	2194	9/24/2002							
16168-M	2194	10/21/2002	0.01	3.86	0.4	4.26	12	1	Ammonia <0.02
16168-M	2194	11/13/2002							
16168-M	2194	12/17/2002							
16168-M	2194	1/28/2003	0.01	4.39	0.1	4.49	12	1	Ammonia <0.02, TKN <0.2
16168-M	2194	2/24/2003							
16168-M	2194	3/19/2003							
16168-M	2194	4/15/2003	0.01	4.47	0.1	4.57	12	1	Ammonia <0.02, TKN <0.2
16168-M	2194	6/16/2003							
16168-M	2194	7/29/2003	0.01	3.74	0.1	3.84	9	1	Ammonia<0.02, TKN<0.2
16168-M	2194	10/14/2003	0.01	3.51	0.1	3.61	8.5	1	Ammonia<0.02, TKN<0.2
16168-M	2195	1/2/2002	0.01	9.21			12		Well development; NH4 <0.02; No TKN result reported.
16168-M	2195	1/2/2002	0.01	9.21			12		QA Duplicate; Well development; No TKN result reported; NH4 <0.02
16168-M	2195	8/27/2002							
16168-M	2195	9/24/2002							
16168-	2195	10/21/2002	0.01	8.25	0.1	8.35	12	1	Ammonia <0.02, TKN <0.2

M									
16168-M	2195	11/13/2002							
16168-M	2195	12/17/2002							
16168-M	2195	1/28/2003	0.02	6.21	0.1	6.31	8.4	1	TKN <0.2
16168-M	2195	2/24/2003							
16168-M	2195	3/19/2003							
16168-M	2195	4/15/2003	0.01	5.23	0.1	5.33	7.1	1	Ammonia <0.02, TKN <0.2
16168-M	2195	6/16/2003							
16168-M	2195	7/29/2003	0.01	6.1	0.1	6.2	8.3	1	Ammonia<0.02, TKN<0.2
16168-M	2195	10/14/2003	0.01	3.84	0.1	3.94	5.4	1	Ammonia<0.02, TKN<0.2
16168-M	2196	1/2/2002	0.01	2.72			2.8		Well development; No TKN result reported; NH4<0.02
16168-M	2196	8/27/2002							
16168-M	2196	9/24/2002							
16168-M	2196	10/21/2002	0.01	0.7	0.1	0.8	1.1	1	Ammonia <0.02, TKN <0.2
16168-M	2196	11/13/2002							
16168-M	2196	12/17/2002							
16168-M	2196	1/28/2003	0.03	0.742	0.1	0.842	1	1	TKN <0.2
16168-M	2196	2/24/2003							
16168-M	2196	3/19/2003							
16168-M	2196	4/15/2003	0.02	1.37	0.1	1.47	1.7	1	TKN <0.2
16168-M	2196	6/16/2003							
16168-M	2196	7/29/2003	0.01	2.73	0.1	2.83	3.7	1	Ammonia<0.02, TKN<0.2
16168-M	2196	10/14/2003	0.01	3.48	0.1	3.58	4.3	1	Ammonia<0.02, TKN<0.2
52588-	2218	5/10/2002	0.04	1.9	0.1	2	3.8		Well development; TKN <0.2

P									
52588-P	2218	6/3/2002	0.03	2.04	0.1	2.14	3.6	1	TKN <0.2
52588-P	2218	7/15/2002							
52588-P	2218	9/9/2002	0.01	1.83	0.3	2.13	4.1	1	
52588-P	2218	11/19/2002	0.01	1.57	0.1	1.67	3.4	1	Ammonia <0.02, TKN <0.2
52588-P	2218	3/3/2003	0.01	1.92	0.1	2.02	3.2	1	NH4AsN <0.02, TKN <0.2
52588-P	2218	6/2/2003	0.01	2.11	0.1	2.21	3.4	1	NH4<0.02, TKN<0.2
52588-P	2218	9/8/2003	0.01	2.27	0.1	2.37	3.9	1	TKN<0.2, NH4AsN<0.02
52588-P	2218	1/26/2004							
52588-P	2218	4/12/2004							
52588-P	2218	7/12/2004							
			Average=	**4.38**					
			Maximum=	**207**					

Table 8. Results from La Pine On-Site Monitoring Well Drain Testing

APPENDIX 2
SAMPLE PARAMETER TABLES

Each table in this appendix provides sample parameter information for the groundwater studies discussed in this report including:

- Sample parameter names.
- Sample parameter CAS Number [in brackets].
- Sample parameter measurement units.
- Sample parameter detection or reporting limits.
- Sample parameter drinking water standard (if applicable).

Table 1
Prineville Groundwater Study (1993)
Volatile Organic Compounds

Notes:

- All measurements in mg/L.
- N.A. = Not Available or Not Applicable.

Constituent	**CAS Number**	**Method Reporting Limit**	**Drinking Water Standard**
Acrolein (2-Propenal)	107-02-8	0.0015	N.A.
Benzene	71-43-2	0.0005	0.005
Bromodichloromethane	75-27-4	0.0005	0.08
Bromoform	75-25-2	0.0005	0.08
Bromomethane	74-83-9	0.0005	N.A.
2-Butanone (MEK)	78-93-3	0.05	N.A.
Carbon Tetrachloride	56-23-5	0.0005	0.005
Chlorobenzene	108-90-7	0.0005	0.1
Chloroethane	75-00-3	0.0005	N.A.
2-Chloroethyl Vinyl Ether	110-75-8	0.005	N.A.
Chloroform	67-66-3	0.0005	0.08
Chloromethane	74-87-3	0.0005	N.A.
Dibromochloromethane	124-48-1	0.0005	0.08
1,2-Dibromoethane (EDB)	106-93-4	0.0005	0.00005
1,2-Dichlorobenzene	95-50-1	0.0005	0.6
1,3-Dichlorobenzene	541-73-1	0.0005	N.A.
1,4-Dichlorobenzene	106-46-7	0.0005	0.075
1,1-Dichloroethane	75-34-3	0.0005	N.A.
1,2-Dichloroethane	107-06-2	0.0005	0.005
cis-1,2-Dichloroethylene	156-59-2	0.0005	N.A.
trans-1,2-Dichloroethylene	156-60-5	0.0005	N.A.
1,1-Dichloroethylene	75-35-4	0.0005	0.007
1,2-Dichloropropane	78-87-5	0.0005	0.005
trans-1,3-Dichloropropene	10061-02-6	0.0005	N.A.
1,2-Dimethylbenzene	95-47-6	0.0005	N.A.
1,3-Dimethylbenzene	108-38-3	0.0005	N.A.
1,4-Dimethylbenzene	106-42-3	0.0005	N.A.
Ethylbenzene	100-41-4	0.0005	0.7
Methylene Chloride	75-09-2	0.0005	0.005
2-Methyl-4-Pentanone (MIBK)	108-10-1	0.005	N.A.
Styrene	100-42-5	0.0005	0.1
1,1,2,2-Tetrachloroethane	79-34-5	0.0005	N.A.
1,1,2,2-Tetrachloroethylene	127-18-4	0.0005	0.005
Toluene	108-88-3	0.0005	1
1,1,1-Trichloroethane	71-55-6	0.0005	0.2
1,1,2-Trichloroethane	79-00-5	0.0005	0.005
Trichloroethylene	79-01-6	0.0005	0.005
Trichlorofluoromethane	75-69-4	0.0005	N.A.
1,2,4-Trimethylbenzene	95-63-6	0.0005	N.A.
Vinyl Chloride	75-01-4	0.0005	0.002

Table 2
Prineville Groundwater Study (1993)
Pesticides

Notes:

- All measurements in mg/L.
- N.A. = Not Available or Not Applicable.

Constituent	CAS Number	Method Reporting Limit	Drinking Water Standard
Aldicarb	116-06-3	0.0036	0.003
Atrazine	1912-24-9	0.0001	0.003
Bromacil	314-40-9	0.0015	N.A.
2,4-D	94-75-7	0.0001	N.A.
Carbofuran	1563-66-2	0.0074	0.04
Dinoseb	88-85-7	0.0001	0.007
Diuron	330-54-1	0.0004	N.A.
Metribuzin	21087-64-9	0.0001	N.A.
Oxamyl	23135-22-0	0.0064	N.A.
Nitrogen/Phosphorus Screen	Various	N.A.	N.A.
OCL Screen	Various	N.A.	N.A.
OP Screen	Various	N.A.	N.A.
Phenoxyherbicide Screen	Various	N.A.	N.A.

Table 3
Prineville Groundwater Study (1993)
Metals, Nutrients, Physical Parameters

Notes:

- All measurements in mg/L.
- N.A. = Not Available or Not Applicable.

Constituent	CAS #	Method Reporting Limit	Drinking Water Standard
Alkalinity	N.A.	1	N.A.
Aluminum	7429-90-5	0.1	N.A.
Ammonia	7664-41-7	0.02	N.A.
Arsenic	7440-38-2	0.005	0.01
Barium	7440-39-3	0.03	2
Beryllium	7440-41-7	0.01	0.004
Boron	7440-42-8	0.03	N.A.
Cadmium	7440-43-9	0.01	0.005
Calcium	7440-70-2	0.1	N.A.
Chemical Oxygen Demand	N.A.	5	N.A.
Chloride	16887-00-6	0.5	N.A.
Chromium	7440-47-3	0.03	0.1
Cobalt	7440-48-4	0.06	N.A.
Conductivity	N.A.	1 µmhos/cm	N.A.
Copper	7440-50-8	0.02	1.3 (Action Level)
Dissolved Oxygen	N.A.	0.1	N.A.
Fluoride	7681-49-4	0.1	4
Hardness	N.A.	3	N.A.
Iron	7439-89-6	0.04	N.A.
Lanthanum	7439-91-0	0.05	N.A.

Lead	7439-92-1	0.005	0.015 (Action Level)
Lithium	7439-93-2	0.05	N.A.
Magnesium	7439-95-4	0.5	N.A.
Manganese	7439-96-5	0.01	N.A.
Nickel	7440-02-2	0.04	N.A.
Nitrate/Nitrite-N	N.A.	0.02	10
pH	N.A.	0.1 S.U.	6.5-8.5
Potassium	7440-09-7	0.5	N.A.
Selenium	7782-49-2	0.005	0.05
Silica	7631-86-9	0.3	N.A.
Silver	7440-22-4	0.01	N.A.
Sodium	7440-23-5	0.5	N.A.
Sulfate	14808-79-8	0.2	N.A.
Temperature	N.A.	0.1^{o}C	N.A.
Total Dissolved Solids	N.A.	1	N.A.
Total Organic Carbon	N.A.	1	N.A.
Vanadium	7440-62-2	0.03	N.A.
Zinc	7440-66-6	0.02	N.A.

Table 4
Statewide Ambient Monitoring Program
Oregon Department of Agriculture Pesticide Screens

Notes:

- Reporting limits in ug/L; Drinking water standards in mg/L.
- N.A. = Not Available or Not Applicable.

Constituent	**CAS #**	**Reporting Limit (ug/L)**	**Drinking Water Standard (mg/L)**
Nitrogen-Phosphorus & Organo Phosphate Screens*			
Alachlor	15972-60-8	0.5	0.002
Atrazine	1912-24-9	0.1	0.003
Bromacil	314-40-9	2.2	N.A
Butachlor	23184-66-9	1.5	N.A
Butylate	2008-41-5	2.0	N.A
Carboxin	5234-68-4	3.0	N.A
Chlorpropham	101-21-3	1.0	N.A
Cycloate	1134-23-2	10.0	N.A
Diphenamid *	957-51-7	2.0	N.A
EPTC (Eptam)	759-94-4	1.0	N.A
Ethoprop *	13194-48-4	0.2	N.A
Fenamiphos *	22224-92-6	0.2	N.A
Hexazinone	51235-04-2	1.0	N.A
Mevinphos *	7786-34-7	0.3	N.A
Metolachlor	51218-45-2	1.0	N.A
Metribuzin	21087-64-9	1.0	N.A
Napropamide	15299-99-7	0.5	N.A
Prometon	1610-18-0	2.0	N.A
Prometryn	7287-19-6	0.2	N.A
Propazine	139-40-2	0.2	N.A
Simazine	122-34-9	0.2	0.004
Tebuthiuron	34014-18-1	0.45	N.A
OCL/Organo Chlorides Screen			
4,4-DDD	72-54-8	0.50	N.A

4,4-DDE	72-55-9	0.50	N.A
4,4-DDT	50-29-3	0.50	N.A
Aldrin	309-00-2	0.50	N.A
Alpha-Chlordane	5103-71-9	0.30	0.002
Alpha-HCH	319-84-6	0.12	N.A
Beta-HCH	319-85-7	0.12	N.A
Chlorothalonil	1897-45-6	0.20	N.A
cis-Permethrin	54774-45-7	1.80	N.A
Dieldrin	60-57-1	0.50	N.A
Endosulfan Sulfate	1031-07-8	0.50	N.A
Endrin	72-20-8	0.10	0.002
Gamma-Chlordane	12789-03-6	0.30	0.002
Gamma-HCH	58-89-9	0.09	N.A
Heptachlor	76-44-8	0.10	0.0004
Heptachlor-epoxide	1024-57-3	0.10	0.0002
Hexachlorobenzene	118-74-1	0.10	0.001
Methoxychlor	72-43-5	0.10	0.04
Propachlor	1918-16-7	1.30	N.A
trans-Permethrin	51877-74-8	1.00	N.A
Trifluralin	1582-09-8	0.50	N.A
Phenoxy Herbicide Screen			
2,4,5-T	93-76-5	0.20	N.A
2,4,5-TP	93-72-1	0.20	N.A
2,4-D	94-75-7	0.30	0.07
2,4-DB	94-82-6	1.00	N.A
DCPA Acid (Dacthal)	1861-32-1	0.10	N.A
Dicamba	1918-00-9	1.00	N.A
Dichlorprop	120-36-5	0.50	N.A
Dinoseb	88-85-7	1.00	0.007
PCP	87-86-5	0.10	0.001
Picloram	1918-02-1	2.00	0.5
HPLC/UV Screen			
Diuron	330-54-1	3	N.A
PCNB (Terachlor)	82-68-8	3.6	N.A
Demeton	8065-48-3	0.2	N.A
Other Pesticides Tested			
Garlon (Triclopyr)	55335-06-3	N.A	N.A
MCPA	94-74-6	N.A	N.A
Terbacil	5902-51-2	N.A	N.A
Triademefon	N.A.	N.A	N.A
Chlordane	12789-03-6	N.A	0.002
Diazinon	333-41-5	N.A	N.A
Captan	133-06-2	N.A	N.A
Silvex	93-72-1	N.A	N.A
Glyphosate	1071-83-6	N.A	0.7
Phorate	298-02-2	N.A	N.A
Dimethoate	60-51-5	N.A	N.A
Dichlobenil	1194-65-6	N.A	N.A
Iprodione	36734-19-7	N.A	N.A
Bladex/Cyanazine	21725-46-2	N.A	N.A
Chlorpyrifos	2921-88-2	N.A	N.A
Norflurazon	27314-13-2	N.A	N.A
Disulfotan	298-04-4	N.A	N.A
Dyfonate/Fonofos	944-22-9	N.A	N.A
AMPA (Glyphosate by product)	N.A.	N.A.	N.A.

	Carbamate Screen		
3-Hydroxycarbofuran	16655-82-6	5	N.A
Aldicarb	116-06-3	1	N.A
Aldicarb Sulfone	1646-88-4	1	N.A
Aldicarb Sulfoxide	1646-87-3	1	N.A
Baygon	114-26-1	1	N.A
Carbaryl	63-25-2	1	N.A
Carbofuran	1563-66-2	1	0.04
Methiocarb	2032-65-7	1	N.A
Methomyl	16752-77-5	1	N.A
Oxamyl	23135-22-0	1	0.2

Table 5
La Pine Groundwater Study (1993)
Volatile Organic Compounds

Notes:

- All measurements in mg/L.
- N.A. = Not Available or Not Applicable.

Constituent	CAS Number	Method Reporting Limit	Drinking Water Standard
Acrolein (2-Propenal)	107-02-8	0.0015	N.A.
Benzene	71-43-2	0.0005	0.005
Bromodichloromethane	75-27-4	0.0005	0.08
Bromoform	75-25-2	0.0005	0.08
Bromomethane	74-83-9	0.0005	N.A.
2-Butanone (MEK)	78-93-3	0.05	N.A.
Carbon Tetrachloride	56-23-5	0.0005	0.005
Chlorobenzene	108-90-7	0.0005	0.1
Chloroethane	75-00-3	0.0005	N.A.
2-Chloroethyl Vinyl Ether	110-75-8	0.005	N.A.
Chloroform	67-66-3	0.0005	0.08
Chloromethane	74-87-3	0.0005	N.A.
Dibromochloromethane	124-48-1	0.0005	0.08
1,2-Dibromoethane (EDB)	106-93-4	0.0005	0.00005
1,2-Dichlorobenzene	95-50-1	0.0005	0.6
1,3-Dichlorobenzene	541-73-1	0.0005	N.A.
1,4-Dichlorobenzene	106-46-7	0.0005	0.075
1,1-Dichloroethane	75-34-3	0.0005	N.A.
1,2-Dichloroethane	107-06-2	0.0005	0.005
cis-1,2-Dichloroethylene	156-59-2	0.0005	N.A.
trans-1,2-Dichloroethylene	156-60-5	0.0005	N.A.
1,1-Dichloroethylene	75-35-4	0.0005	0.007
1,2-Dichloropropane	78-87-5	0.0005	0.005
cis-1,3-Dichloropropene	10061015	0.0005	N.A.
trans-1,3-Dichloropropene	10061-02-6	0.0005	N.A.
1,2-Dimethylbenzene	95-47-6	0.0005	N.A.
1,3-Dimethylbenzene	108-38-3	0.0005	N.A.
1,4-Dimethylbenzene	106-42-3	0.0005	N.A.
Ethylbenzene	100-41-4	0.0005	0.7
Methylene Chloride	75-09-2	0.0005	0.005
2-Methyl-4-Pentanone (MIBK)	108-10-1	0.005	N.A.
Styrene	100-42-5	0.0005	0.1

1,1,2,2-Tetrachloroethane	79-34-5	0.0005	N.A.
1,1,2,2-Tetrachloroethylene	127-18-4	0.0005	0.005
Toluene	108-88-3	0.0005	1
1,1,1-Trichloroethane	71-55-6	0.0005	0.2
1,1,2-Trichloroethane	79-00-5	0.0005	0.005
Trichloroethylene	79-01-6	0.0005	0.005
Trichlorofluoromethane	75-69-4	0.0005	N.A.
1,2,4-Trimethylbenzene	95-63-6	0.0005	N.A.
Vinyl Chloride	75-01-4	0.0005	0.002

Table 6
La Pine Groundwater Study (1993)
Pesticides

Notes:

- All measurements in mg/L.
- N.A. = Not Available or Not Applicable.

Constituent	CAS Number	Method Reporting Limit	Drinking Water Standard
Atrazine	1912-24-9	0.0001	0.003
Bromacil	314-40-9	0.0022	N.A.
2,4-D	94-75-7	0.0005	N.A.
Diuron	330-54-1	0.0005	N.A.
Diclobenil	1194-65-6	0.0006	N.A.
Dicamba	1918-00-9	0.0002	N.A.
Picloram	1918-02-1	0.0002	0.5

Table 7
La Pine Groundwater Study (1993)
Metals, Nutrients, Physical Parameters

Notes:

- All measurements in mg/L.
- N.A. = Not Available or Not Applicable.

Constituent	CAS #	Method Reporting Limit	Drinking Water Standard
Alkalinity	N.A.	1	N.A.
Aluminum	7429-90-5	0.1	N.A.
Ammonia	7664-41-7	0.02	N.A.
Arsenic	7440-38-2	0.005	0.01
Barium	7440-39-3	0.03	2
Beryllium	7440-41-7	0.01	0.004
Boron	7440-42-8	0.03	N.A.
Cadmium	7440-43-9	0.01	0.005
Calcium	7440-70-2	0.1	N.A.
Chemical Oxygen Demand	N.A.	5	N.A.
Chloride	16887-00-6	0.5	N.A.
Chromium	7440-47-3	0.03	0.1
Cobalt	7440-48-4	0.06	N.A.
Conductivity	N.A.	1 µmhos/cm	N.A.

Copper	7440-50-8	0.02	1.3 (Action Level)
Hardness	N.A.	3	N.A.
Iron	7439-89-6	0.04	N.A.
Lanthanum	7439-91-0	0.05	N.A.
Lead	7439-92-1	0.005	0.015 (Action Level)
Lithium	7439-93-2	0.05	N.A.
Magnesium	7439-95-4	0.5	N.A.
Manganese	7439-96-5	0.01	N.A.
Mercury	7439-97-6	0.0005	0.002
Molybdenum	7439-98-7	0.05	N.A.
Nickel	7440-02-2	0.04	N.A.
Nitrate/Nitrite-N	N.A.	0.02	10
pH	N.A.	0.1 S.U.	6.5-8.5
Potassium	7440-09-7	0.5	N.A.
Selenium	7782-49-2	0.005	0.05
Silica	7631-86-9	0.3	N.A.
Silver	7440-22-4	0.01	N.A.
Sodium	7440-23-5	0.5	N.A.
Sulfate	14808-79-8	0.2	N.A.
Temperature	N.A.	0.1^{o}C	N.A.
Total Dissolved Solids	N.A.	1	N.A.
Total Kjeldahl Nitrogen	N.A.	0.2	N.A.
Total Organic Carbon	N.A.	1	N.A.
Total Phosphate	N.A.	0.01	N.A.
Turbidity	N.A.	1 NTU	N.A.
Vanadium	7440-62-2	0.03	N.A.
Zinc	7440-66-6	0.02	N.A.

Department of Environmental Quality

DEQ Home (http://www.deq.state.or.us/)/ Water Quality (http://www.oregon.gov/DEQ/WQ/)/ Databases (http://www.deq.state.or.us/wq/catlist.htm#db) / Wastewater Permits Data (sisdata.asp) / Facility Details

Wastewater Permits Database - Facility Details

Active Permits for OREGON MILITARY DEPARTMENT - WQ File Number: 111416

The permits listed below are the currently active permits for this facility. If you wish to see details on the applications that led to these permits click on the application number below.

If you wish to see the details on any pending applications for this facility click here (facapplpend.asp?facilityidreq=111416).

Field	Record
Legal Name	OREGON MILITARY DEPARTMENT
Common Name	OMD - REDMOND COUTES
Street Address	2899 E. HIGHWAY 126
City	REDMOND
Zip Code	97756
County	DESCHUTES
DEQ Region	ER
Primary SIC Code	9711
Facility Type Description	DEPARTMENT OF DEFENSE
Latitude	44.2541
Longitude	-121.1333
Permit Type	GEN17B
Permit Description	Industrial Wastewater; WPCF wash water
Category	IND
Class	N/A
Start Date	8/10/2001
Expiration Date	10/31/2017
Active Permit	True
UIC Facility	True
Administrative Agent	Pendleton Office
Last Action Date	8/21/2017
Last Action Description	Admin extended
Permit Writer	Ratliff
Compliance Inspector	Ratliff

DMR Reviewer	Ratliff
Permit Application Number	954198 (facilityappl.asp?applnumberreq=954198)
EPA Number	n/a

Department of Environmental Quality (http://www.oregon.gov/DEQ/)
700 NE Multnomah Street, Suite 600 Portland, OR 97232
Hours: Mon-Fri, 8 a.m.-5 p.m
Email: DEQInfo@deq.state.or.us (mailto:DEQInfo@deq.state.or.us) | Phone: 503-229-5696 | Fax: 503-229-6124

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Accessibility (http://www.oregon.gov/pages/accessibility.aspx)
Privacy Policy (http://www.oregon.gov/DAS/ETS/EGOV/pages/termsconditions.aspx)

Department of Environmental Quality

DEQ Home (http://www.deq.state.or.us/)/ Water Quality (http://www.oregon.gov/DEQ/WQ/)/ Databases (http://www.deq.state.or.us/wq/catlist.htm#db) / Wastewater Permits Data (sisdata.asp) / Facility Details

Wastewater Permits Database - Facility Details

Active Permits for OREGON MILITARY DEPARTMENT - WQ File Number: 111416

The permits listed below are the currently active permits for this facility. If you wish to see details on the applications that led to these permits click on the application number below.

If you wish to see the details on any pending applications for this facility click here (facapplpend.asp?facilityidreq=111416).

Field	Record
Legal Name	OREGON MILITARY DEPARTMENT
Common Name	OMD - REDMOND COUTES
Street Address	2899 E. HIGHWAY 126
City	REDMOND
Zip Code	97756
County	DESCHUTES
DEQ Region	ER
Primary SIC Code	9711
Facility Type Description	DEPARTMENT OF DEFENSE
Latitude	44.2541
Longitude	-121.1333
Permit Type	GEN17B
Permit Description	Industrial Wastewater; WPCF wash water
Category	IND
Class	N/A
Start Date	8/10/2001
Expiration Date	10/31/2017
Active Permit	True
UIC Facility	True
Administrative Agent	Pendleton Office
Last Action Date	8/21/2017
Last Action Description	Admin extended
Permit Writer	Ratliff
Compliance Inspector	Ratliff

DMR Reviewer	Ratliff
Permit Application Number	954198 (facilityappl.asp?applnumberreq=954198)
EPA Number	n/a

Department of Environmental Quality (http://www.oregon.gov/DEQ/)
700 NE Multnomah Street, Suite 600 Portland, OR 97232
Hours: Mon-Fri, 8 a.m.-5 p.m
Email: DEQInfo@deq.state.or.us (mailto:DEQInfo@deq.state.or.us) | Phone: 503-229-5696 | Fax: 503-229-6124

Website Feedback (http://www.oregon.gov/Pages/website_feedback.aspx?address=deqwebmaster@deq.state.or.us)
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Privacy Policy (http://www.oregon.gov/DAS/ETS/EGOV/pages/termsconditions.aspx)

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE ARMY
U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
5158 BLACKHAWK ROAD
ABERDEEN PROVING GROUND, MARYLAND 21010-5403

REPLY TO
ATTENTION OF

MCHB-TS-EGW (40) 04 JUN 2002

MEMORANDUM FOR The State of Oregon, Oregon Military Department (Gerald Elliott), 1776 Militia Way, SE, P.O. Box 14350, Salem, OR 97309-5047

SUBJECT: Site Assessment Survey No. 38-EH-5048B-01, Oregon Army National Guard, Central Oregon Unit Training and Equipment Site (COUTES), Redmond, Oregon, 11-12 July 2001

One paper copy of subject report and a CD-ROM are enclosed.

FOR THE COMMANDER:

John W. Bauer

Encl

JOHN W. BAUER, P.G.
Program Manager
Ground Water and Solid Waste

CF(w/encl):
DIR, POPM-SA, ATTN: MCPO-SA (EXSUM ONLY)
C, NGB, ATTN: NGB-ARE-I
CDR, MAMC, ATTN: PVNTMED SVC (EXSUM ONLY)
CDR, USAEC, ATTN: SFIM-AEC-PC
CDR, USAEC, ATTN: TECH INFO CTR
CDR, USACHPPM-W

Readiness thru Health

U.S. Army Center for Health Promotion and Preventive Medicine

U
S
C
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SITE ASSESSMENT SURVEY NO. 38-EH-5048B-01
OREGON ARMY NATIONAL GUARD
CENTRAL OREGON UNIT TRAINING AND EQUIPMENT SITE (COUTES)
REDMOND, OREGON
11-12 JULY 2001

Approved for public release; distribution unlimited.

Readiness Thru Health

DEPARTMENT OF THE ARMY
U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
5158 BLACKHAWK ROAD
ABERDEEN PROVING GROUND, MARYLAND 21010-5403

REPLY TO
ATTENTION OF

04 JUN 2002

EXECUTIVE SUMMARY
SITE ASSESSMENT SURVEY NO. 38-EH-5048B-01
OREGON ARMY NATIONAL GUARD
CENTRAL OREGON UNIT TRAINING AND EQUIPMENT SITE (COUTES)
REDMOND, OREGON
11-12 JULY 2001

1. PURPOSE.

The purpose of the Site Assessment Survey (SAS) was to document the environmental condition of Oregon Army National Guard's (ORARNG) Central Oregon Unit Training and Equipment Site (COUTES) and to determine the need for further action at any locations where a release of hazardous constituents is suspected. This was accomplished by reviewing the historical and current activities conducted at the COUTES and by evaluating the impact of those activities on the potential pathways through which migration of contaminants may affect public health and the environment.

2. CONCLUSIONS.

2.1. PATHWAYS AND TARGETS.

2.1.1. General. For a pathway to be complete, there must be a source with a release of hazardous constituents to some environmental media (e.g. soil, air, water, sediment), a transport mechanism between the media and an exposure point (e.g. indoor air, outside air, soil in yard, water in well), and exposure routes (e.g. oral, inhalation, dermal) between the exposure point and a human receptor. If any of these steps do not exist, then the pathway is not complete.

2.1.2. Ground Water. The ground-water pathway is not complete from a source to a target. There were no documented releases to ground water. Although the wash rack and its associated former and active treatment systems are potential sources of subsurface soil contamination, upgrades and discontinuation of use have reduced the potential impact to ground water. Although a large number of active drinking water wells (including the COUTES well) exist within the area, none would be likely to be affected by operations at the COUTES.

2.1.3. Surface Water. The surface water pathway is not complete from a source to a target because there are no drinking water intakes downstream from the COUTES.

2.1.4. Soil and Air. Most of the operations at the COUTES are inside buildings and therefore are not likely to affect surface soil or air quality. Although releases of hazardous substances to soil have been documented from the former settling pond and French drain, the system is no longer used. The potential for soil entrainment into the air is high. Although fine particles from the gravel-covered areas could become airborne, no hazardous constituents were present. There are no residences, schools, or childcare facilities within 200 feet of the site.

2.2. POTENTIAL SOURCE AREAS.

The wash rack and its associated treatment systems (former settling pond, French drain, and sprinkler irrigation) have released low concentrations of total petroleum hydrocarbons (diesel range), PCE, and metals into the shallow subsurface soil. However, due to discontinuation of use, upgrading of the OWS, low concentrations, and the lack of targets, additional sampling is not necessary or recommended at the potential source.

2.3. PREVENTIVE MEASURES.

Although sampling is not recommended at any of the environmentally significant operations, some measures should be taken to prevent regulatory action, adverse effects to human health, or environmental contamination. The COUTES well is located less than 10 feet from the outdoor weapon cleaning area, making it vulnerable to spills and discharges. Although the roof helps to protect the area from precipitation that could carry any contamination to deeper soils, spills and drips from the parts washers may contaminate the surface soil beneath the gravel. A bermed concrete pad for the area would prevent any discharges from reaching soil or ground water.

3. RECOMMENDATIONS.

3.1. Environmental sampling is not recommended at any of the described operations.

3.2. Construct a concrete pad with a berm for the outdoor weapon cleaning area.

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DEPARTMENT OF THE ARMY
U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
5158 BLACKHAWK ROAD
ABERDEEN PROVING GROUND, MARYLAND 21010-5403

REPLY TO
ATTENTION OF

MCHB-TS-EGW

SITE ASSESSMENT SURVEY NO. 38-EH-5048B-01
OREGON ARMY NATIONAL GUARD
CENTRAL OREGON UNIT TRAINING AND EQUIPMENT SITE (COUTES)
REDMOND, OREGON
9-10 JULY 2001

1. INTRODUCTION.

1.1. REFERENCES.

Appendix A contains a list of references used in preparing this report.

1.2. AUTHORITY.

Telephone conversation between Mr. John W. Bauer, U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM), and Mr. Gerald E. Elliott, Oregon Military Department (OMD), 14 April 2000, subject: Scheduling of Site Assessment Surveys at Sites in Oregon.

1.3. PURPOSE.

The purpose of the Site Assessment Survey (SAS) was to document the environmental condition of Oregon Army National Guard (ORARNG) Central Oregon Unit Training and Equipment Site (COUTES) and to determine the need for further action at any locations where a release of hazardous constituents is suspected. This was accomplished by reviewing the historical and current activities conducted at the COUTES and by evaluating the impact of those activities on the potential pathways through which migration of contaminants may affect public health and the environment.

1.4. PROCEDURES.

This SAS was conducted by Ms. Kim M. Fleischmann, an Environmental Scientist from USACHPPM. During 3-6 July 2001, Ms. Fleischmann visited the OMD Environmental Office to collect background information on the COUTES. During 11-12 July 2001, Ms. Fleischmann visited the COUTES and its surroundings. The scope of the SAS included activities conducted at the site only since the ORARNG first began leasing the land, from 1973 to the present. The investigation was conducted through research and review of documentation from Federal, State and local government offices [OMD, U.S. Department of Agriculture Natural Resources Conservation Service, Oregon Department of Environmental Quality (ORDEQ), Oregon Department of Geology and Mineral Industries, Oregon Water Resources Department, and City of Redmond], interviews with current site employees, and offsite and onsite reconnaissance. No environmental samples were collected or analyzed during this SAS. The U.S. Environmental Protection Agency's (EPA) Guidance for Performing Preliminary Assessments Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) was used to focus this investigation.

1.5. PERSONNEL CONTACTED.

Appendix B contains a list of personnel contacted during the SAS.

2. SITE DESCRIPTION.

2.1. LOCATION AND MISSION.

The COUTES is located on 6.4 acres of land leased from the city of Redmond and on a 2.3-acre portion of 36 acres of State-owned land in Deschutes County, Oregon (reference 1) (Figure 1). The site is located 2½ miles southeast of the center of Redmond and ½ mile south of Highway 126 (also called Ochoco Highway). The address is 2899 Highway 126 East, Redmond, Oregon 97756. It is situated in Section 23 of Township 15 South and Range 13 East of the Willamette Meridian, at approximately N 44°16'08" latitude and W 121°12'01" longitude. Figure 2 shows the site layout of the property. The COUTES maintains and stores tracked vehicles and wheeled vehicles for the 1249th Engineer Battalion (headquarters, A Company, and B Company) and to Troops E, F, and G of the 82nd Cavalry Battalion.

2.2. PHYSIOGRAPHY.

The COUTES is located in the High Lava Plains province, east of the High Cascade Mountains province. The High Lava Plains province is a relatively flat plateau. The COUTES property is nearly level with an approximate elevation of 3,050 feet above mean sea level (reference 2).

2.3. CLIMATE.

According to the Oregon Climate Service (reference 3), Redmond is located within Oregon Climate Zone 7 – South Central. The climate of the Redmond area is classified as high desert. It is semi-arid and sunny with four distinct seasons (reference 4). Mean temperatures range from 31 degrees Fahrenheit (°F) in January to 66°F in July. The average low temperature is 21°F in

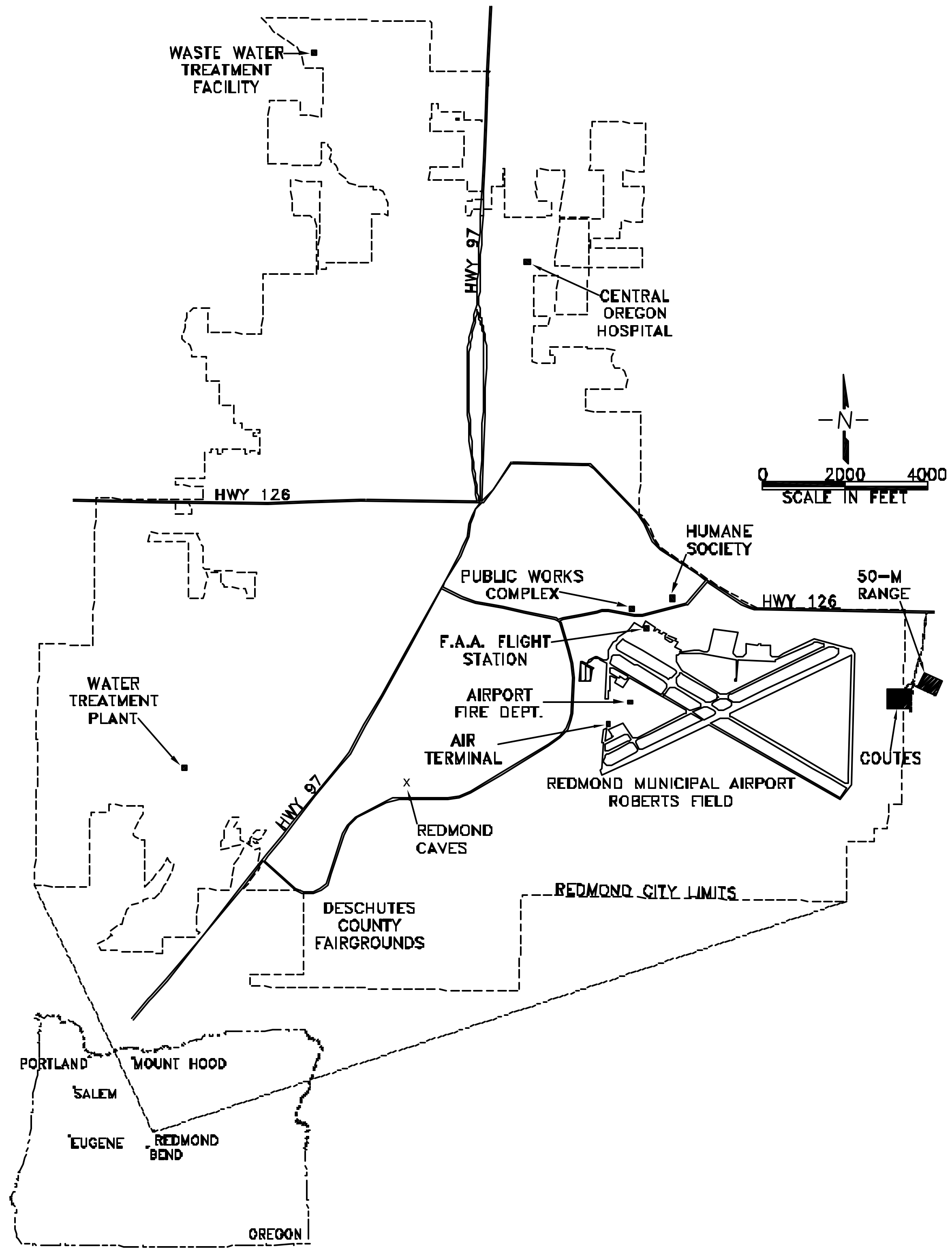

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FIGURE 1
LOCATION OF THE COUTES
REDMOND, OREGON.

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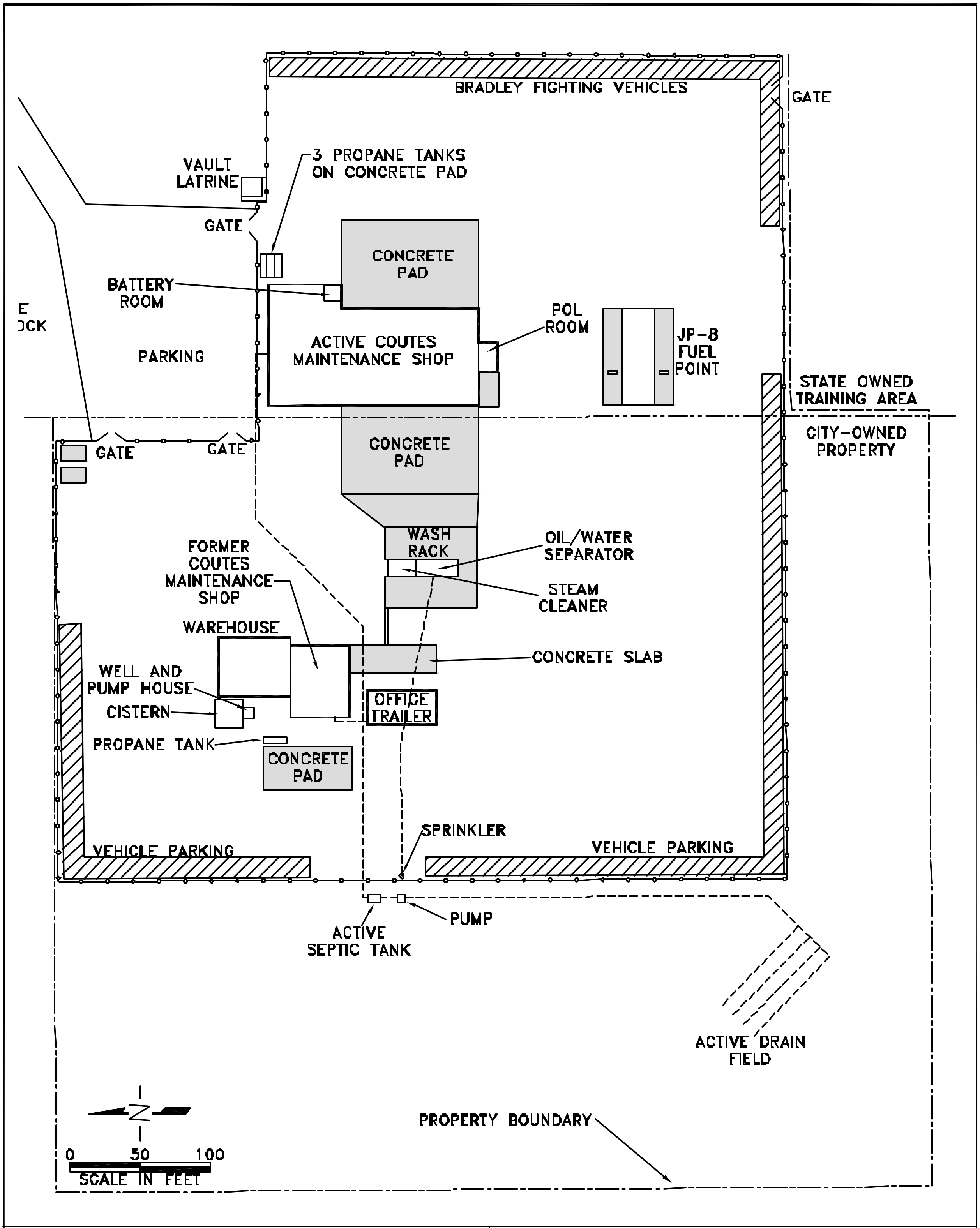

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FIGURE 2.
SITE PLAN OF THE COUTES
REDMOND, OREGON.

DRAWN BY:	PROJ #:	FILE:
GCL	38-EH-5048B-02	OR/COUTES/5048BSTE

January and December, and the average high temperature is 85°F in July. Annual average precipitation is 8.62 inches, with the heaviest received in November, December, and January (slightly more than 1 inch per month) (reference 5). Yearly snowfall is 20 inches. The wind typically blows 4 to 7 miles per hour, primarily from the south-southeast and west-northwest during the winter months and from the west-northwest and north-northwest during the summer months. March and October are transitional months for wind direction (reference 3). Weather data for the Redmond area are tabulated in Table 1.

Table 1. Monthly Climate Averages and Records for Redmond, OR.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Avg. High Temp	41°F	47°F	52°F	59°F	67°F	76°F	85°F	83°F	75°F	64°F	49°F	41°F
Avg. Low Temp	21°F	24°F	26°F	28°F	34°F	42°F	46°F	46°F	38°F	32°F	27°F	21°F
Mean Temp	31°F	36°F	40°F	44°F	51°F	59°F	66°F	65°F	57°F	48°F	38°F	32°F
Avg. Precipitation (inches)	1.10	0.60	0.70	0.60	0.70	0.70	0.50	0.60	0.40	0.50	1.20	1.10
Record High Temp & Year Recorded	67°F (1999)	73°F (1995)	80°F (1966)	89°F (1968)	99°F (1986)	101°F (1968)	105°F (1968)	108°F (1972)	105°F (1998)	95°F (1970)	76°F (1997)	67°F (1965)
Record Low Temp & Year Recorded	-27°F (1962)	-19°F (1989)	-1°F (1955)	10°F (1972)	12°F (1964)	24°F (1976)	28°F (1962)	25°F (1960)	16°F (1961)	4°F (1971)	-14°F (1955)	-28°F (1972)

Source: reference 5.

2.4. ADJACENT LAND USE AND POPULATION.

The COUTES is surrounded by land owned by the city of Redmond, the OMD, Deschutes County, and the Department of the Interior Bureau of Land Management (BLM). The Redmond Municipal Airport (Roberts Field) is owned by the city of Redmond and is located directly west of the COUTES. The OMD owns approximately 36 acres of adjoining land to the east of the COUTES. The OMD built the active COUTES maintenance building and the 50-meter small arms firing range on the land in 1990. Over 31,000 acres of land located to the north and south of the COUTES is owned by Deschutes County and BLM and is used by the ORARNG for the Biak Training Center (BTC), formerly called Central Oregon Training Site (COTS). Under a Special Land Use Permit with the BLM, the BTC has been used since 1959 as a relatively unimproved and natural field environment for battalion-level and company-level training by mounted and dismounted infantry, armor, cavalry, and engineers. The mostly undeveloped land is vegetated with juniper and sagebrush (reference 1). The nearest residential homes are located in the city of Redmond more than 1 mile to the northwest. As of the 2000 census (reference 6), the population of Redmond was 13,481 people, and the population of Deschutes County was 115,367 people.

2.5. SURFACE WATER AND STORM WATER DRAINAGE.

There are no natural surface water features on the COUTES property. The scant amount of precipitation that falls on the COUTES quickly percolates into the first few inches of soil or quickly evaporates in the dry atmosphere. Storm water does not drain to any nearby surface water bodies. However, the 15-mile downstream flow route for the nearest surface water drainage is shown in Figure 3. Located less than 1 mile to the east, the North Unit Main Canal is the nearest surface water body. The North Unit Main Canal contains water diverted in Bend, Oregon, from the Deschutes River, but it only carries irrigation water during spring and summer growing seasons. Flow is terminated in late October or early November and reopened in the spring (reference 1). Water in the canal flows north and northeast, entering the Crooked River southeast of Smith Rock State Park. The Crooked River flows northwest through the Crooked River Gorge and joins the Deschutes River at Lake Billy Chinook in The Cove Palisades State Park. After flowing through the Round Butte Dam, the Deschutes River flows north and northeast to enter the Columbia River upstream of the city of The Dalles. The Columbia River flows west to the Pacific Ocean.

2.6. SOILS.

Descriptions of the soils in Redmond and Deschutes County are contained in reference 7. The entire COUTES property is covered with soil classified as the Deschutes-Stukel Complex. Both the Deschutes series soils and the Stukel series soils are found on lava plains. The Deschutes series consists of well-drained soils formed in loess and ash. The surface layer is grayish brown sandy loam 17 inches thick. The subsoil is grayish brown and light grayish brown sandy loam, 14 inches thick, over basalt. The Stukel series consists of well drained soils formed in ash over residuum. The surface layer is grayish brown sandy loam, 4 inches thick. The next layer is brown cobbly sandy loam clay, 7 inches thick. The substratum is pale brown gravelly sandy loam, 7 inches thick, over bedrock. Permeability rates for the soils of the Deschutes-Stukel Complex are 2.0 to 6.0 inches per hour (moderately rapid).

2.7. GEOLOGY.

The COUTES is underlain by 10- to 100-feet thick Quaternary-age basalt and basaltic andesite lava flows, most of which were deposited approximately 7,000 years ago. The lava flows originated from the Newberry strato-composite volcano and fissure vents along its flanks. Now known as the Newberry National Volcanic Monument, the crater is located within the boundaries of the Deschutes National Forest, approximately 45 miles south of Redmond. Beneath the Quaternary lava flows are late Tertiary-age basalt flows interlayered with volcaniclastic sedimentary rocks (references 1, 8, 9, and 10).

2.8. GROUND WATER.

Ground water exists in the fracture zones and voids of the Quaternary and Tertiary lava flows and in the more permeable zones of the sedimentary rocks. Regional depth to ground water is 600 to 800 feet below ground surface, and flow is generally to the north and northeast. Ground water discharges to the canyons of the Deschutes and Crooked Rivers (reference 11). One drinking water well was drilled on the COUTES property in 1979. The well is 425 feet deep and

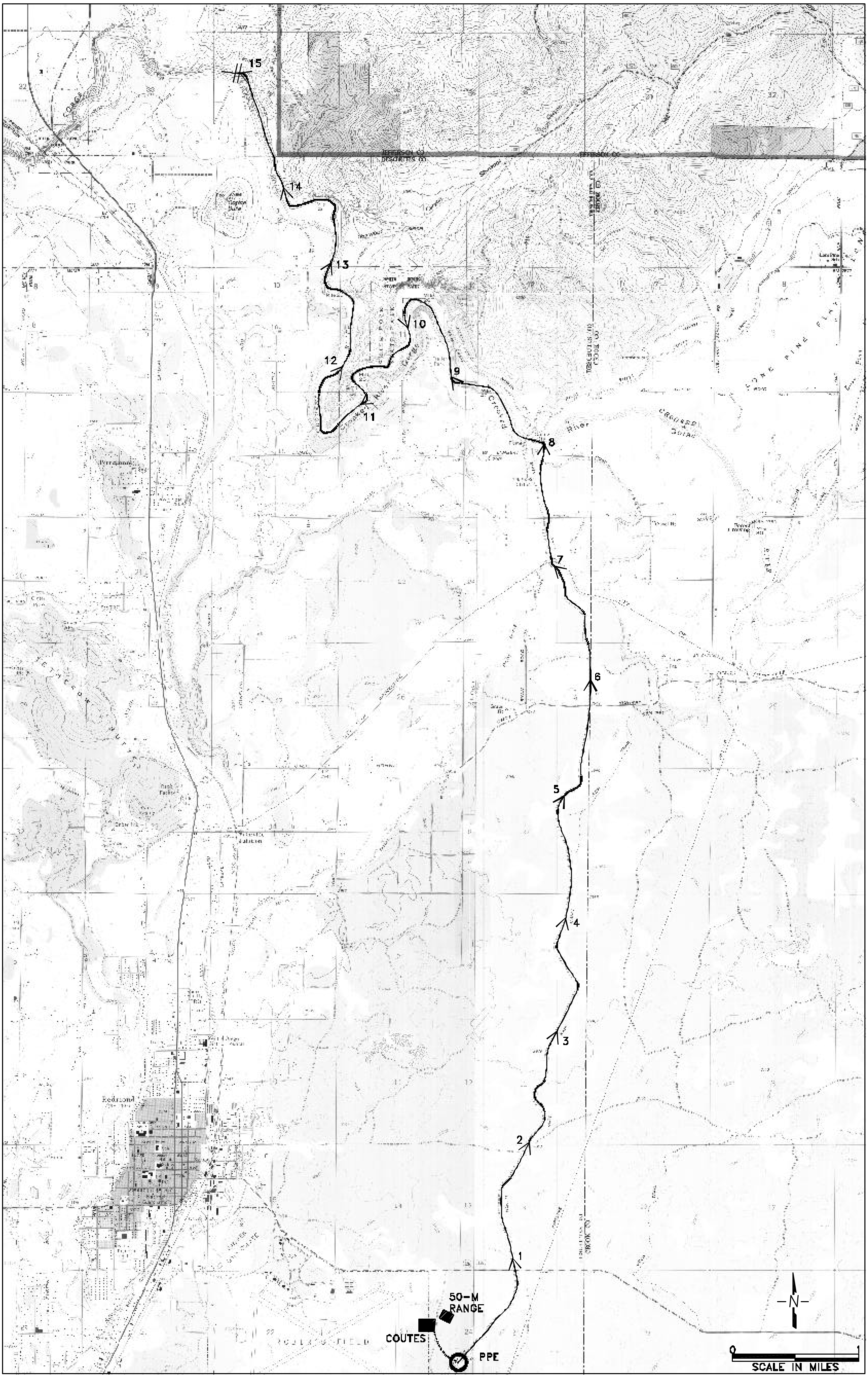

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FIGURE 3.
MAP OF 15-MILE SURFACE WATER
MIGRATION ROUTE DOWNSTREAM OF THE COUTES.

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GCL	38-EH-5048B-02	OR/COUTES/5048B15M

depth to water is approximately 375 feet below ground surface (reference 12). A copy of the well log is contained in Appendix C.

2.9. SENSITIVE ENVIRONMENTS.

2.9.1. Endangered and Threatened Species.

Table 2 lists the Federal and State, endangered, threatened and candidate species for Deschutes County according to the Oregon Natural Heritage Program (reference 13).

Table 2. Endangered, Threatened, and Candidate Species in Deschutes County.

COMMON NAME	SCIENTIFIC NAME	STATUS
bull trout	*Salvelinus confluentus*	Federal listed threatened
Oregon spotted frog	*Rana pretiosa*	Federal candidate
northern spotted owl	*Strix occidentalis caurina*	Federal and State listed threatened
California wolverine	*Gulo gulo luteus*	State listed threatened
Canada lynx	*Lynx Canadensis*	Federal listed threatened
kit fox	*Vulpes macrotis*	State listed threatened
Peck's milk-vetch	*Astralagus peckii*	State listed threatened
pumice grape-fern	*Botrychium pumicola*	State listed threatened

Source: reference 13.

2.9.2. Wetlands, Fisheries, and Hatcheries.

No wetlands occur on the COUTES. The nearest wetlands occur along the North Unit Main Canal, which is identified as an intermittent riverine, semi-permanently flooded wetland (reference 1). No hatcheries or commercial fisheries are located downstream of the COUTES. Sport fishing for brown trout, rainbow trout, and steelhead is common in the Deschutes River and Crooked River. Lake Billy Chinook (the reservoir formed by the confluence of the Deschutes, Crooked, and Metolious Rivers behind the Round Butte Dam) is also a popular sport fishing location for rainbow trout, brown trout, bull trout, smallmouth bass, crappie, and kokanee (reference 14).

3. OPERATIONAL HISTORY AND WASTE CHARACTERISTICS.

3.1. GENERAL SITE HISTORY.

3.1.1. Land Leases.

On 28 June 1973, the OMD leased 2.5 acres of land for 20 years from the Redmond Airport Commission for $1.00 per year (reference15). The original use of the site was as a storage area for the BTC (reference 1). The first COUTES maintenance shop and associated support structures were later constructed on this parcel. The property boundaries are described in the lease as:

> "Commencing at a point on the east boundary of Roberts Field,
> said point being N. 89° 51′ 00″ W., 1304.99 feet; thence S. 0° 04′

> 27″ E., 2135.70 feet from the NE corner of Section 23, Township 15 South Range 13 East of the Willamette Meridian in Deschutes County, Oregon; thence S. 89° 55′ 23″ W., a distance of 215.00 feet, more or less, to an iron pipe; thence S. 0° 04′ 27″ E., a distance of 500.00 feet to an iron pipe; thence N. 89° 55′ 23″ E., a distance of 215.00 feet, more or less, to the east boundary of Roberts Field; thence N. 0° 04′ 27″ W. along the east boundary of Roberts Field a distance of 500.00 feet to the point of beginning, containing 2½ acres, more or less."

On 19 March 1986, the city of Redmond extended the property boundaries in an addendum to the original lease agreement (reference16). The property size was increased to 6.40 acres to accommodate the new office trailer and new septic tank and drain field system. On 13 January 1987, the lease was renewed for 20 years until 31 December 2007 (reference 17). The new property boundaries are described in the lease as:

> "Commencing at a point on the East boundary of Roberts Field, said point being North 89° 51′ 00″ West, 1304.99 feet; thence South 0° 04′ 27″ East, 2135.70 feet from the Northeast corner of Section 23, Township 15 South Range 13 East of the Willamette Meridian in Deschutes County, Oregon; thence South 89° 55′ 23″ West, a distance of 465.00 feet, more or less; thence South 0° 04′ 27″ East, a distance of 600.00 feet; thence North 89° 55′ 23″ East, a distance of 465.00 feet, more or less, to the East boundary of Roberts Field; thence North 0° 04′ 27″ West along the east boundary of Robers [sic] Field a distance of 600.00 feet to the Point of Beginning; containing 6.4 acres, more or less."

3.1.2. Land Acquisitions.

On 23 November 1987, Deschutes County conveyed to the OMD approximately 36 acres of land directly east of and adjacent to the COUTES property (reference 18). The active COUTES maintenance building was constructed on part of the new property in 1989-90. A 50-meter range was also constructed on the property in 1990. The scope of the SAS did not include the 50-meter range. The property boundaries of the 36 acres are described in the deed as:

> "That portion of the Northeast one-quarter of Section 23, Township 15 South, Range 13 East of the Willamette Meridian, lying easterly of the East boundary of the Redmond Municipal Airport (Roberts Field) and being the Easterly 1337.8 feet, more or less, of the Northeast one-quarter of Section 23, Township 15 South, Range 13 East of the Willamette Meridian, Deschutes County, Oregon.
>
> Excepting therefrom the following described parcel:

> Beginning at the Northeast corner of said Section 23; thence Southerly along the East line of said Section, 1086 feet, more or less; thence leaving said section line South 60° 31′ 00″ West 1540 feet, more or less, to a point on the East Boundary of the Redmond Municipal Airport (Roberts Field); thence Northerly along said boundary 1845 feet, more or less, to the northeast corner of said Airport property, said point also being on the North line of said Section 23; thence Easterly 1337.8 feet, more or less, to the Northeast corner of said Section 23, said corner being the point of beginning and terminus of this description."

3.1.3. Easements.

On 29 October 1991, the OMD granted an easement and right-of-way 10 feet wide to Pacific Power and Light Company for an underground electric distribution line across the State-owned 36-acre property.

3.2. REGULATORY ACTIVITIES.

The COUTES is a conditionally exempt small quantity generator of hazardous waste. Its EPA facility identification (ID) is OR1211841175, its EPA handler ID is ORD980987705, and its ORDEQ facility ID is 111416/A. According to site personnel, and corroborated by disposal manifests, potentially hazardous waste (typically used oil, used hydraulic fluid, used brake fluid, and used antifreeze) is disposed through the Defense Reutilization and Marketing Office (DRMO). Site personnel call the U.S. Property and Fiscal Office (USPFO) or the OMD Environmental Office to arrange for pickup of the waste by DRMO's contractor. According to reference 19, the COUTES does not have a permitted discharge to water [National Pollutant Discharge Elimination System (NPDES) permit], has never reported a toxic release or an air release, and is not listed in the CERCLA information system (CERCLIS). On 5 July 2001, OMD submitted to the ORDEQ an application for a general Water Pollution Control Facility (WPCF) permit for the wash rack and sprinkler irrigation system (reference20). On 10 August 2001, the ORDEQ issued a WPCF general permit 1700-B (wash water) to the COUTES (references 21 and 22). WPCF permits are required by state statute, are issued by ORDEQ, and generally cover all discharges not covered by an NPDES permit, including discharges to ground water. No large spills, noncompliances, or notices of noncompliance have been reported for COUTES.

3.3. GENERAL BUILDING DESCRIPTION AND USE.

3.3.1. Former COUTES Maintenance Shop (Active Storage Building).

The first COUTES maintenance shop was built during 1978-79 on the 2.5-acre leased property. It is a steel-sided building built on a concrete slab (40 feet by 50 feet). The eastern half of the building originally had a drive-through two-story maintenance bay with two rollup doors and an overhead crane. The western half of the building is one story. It was originally equipped with locker room, a latrine (toilet, sink, and shower), a mechanical room (hot water heater), a warehouse area, a supply room, and a tool room. The former COUTES maintenance shop is now used as a storage building. It contains a secure ammunition vault inside the old maintenance bay and a communications equipment storage room in the old locker room area. A weapon cleaning area is located under an open-air roof outside the door on the east side of the building. A warehouse/storage building is attached to the north side of the building.

3.3.2. Warehouse/Storage Building.

The warehouse/storage building is located north of the former COUTES maintenance shop and is connected by a door. It was constructed some time between 1987 and 1989, and is a steel-sided one-story building built on a concrete slab (50 feet by 40 feet). The building contains a tool bay and equipment storage and issue points for Troops E and F.

3.3.3. Active COUTES Maintenance Shop.

The second COUTES maintenance shop was built during 1989-90 on a portion of the OMD-owned 36 acres. The L-shaped building has a combination of steel siding and brick façade, and was constructed on concrete slabs. The one-story administrative and storage area is 50 feet 5 inches by 81 feet 4 inches. It contains two offices, two tool rooms, supply room, locker room, men’s latrine (toilet, urinal, two sinks, shower), women’s latrine (toilet, sink, shower), kitchen (sink), break room, mechanical room, custodial closet (slop sink), and battery room. The plumbing fixtures are connected to the active septic tank and drain field system. The battery room is located on the southeast corner of the admin building and is accessible only from an outside door. It is equipped with a sink, eyewash, and shower. The sink and the floor drain under the eyewash and shower are connected to the wash rack’s wastewater treatment system. Employees serviced batteries in the room for approximately 3 years, but the room now contains batteries on shelves, three flammable materials storage cabinets, and miscellaneous dry storage. Personnel no longer handle acids to service batteries because new batteries are delivered and exchanged for old batteries under a contract. The two-story maintenance bay is 95 feet 2 inches by 65 feet 4 inches. It contains three large drive-through bays (or six small drive-in bays) with trench floor drains at each of the six doorways. The former used oil sump is located on the south end of the maintenance bay. An extension (19 feet 4 inches by 12 feet 8 inches) outside the south end of the shop contains the petroleum, oil, and lubricants (POL) storage room. The POL storage room is used only for new POL material and can be accessed via a door from inside the maintenance shop or via an outside door. The COUTES personnel change fluids, tires, and brakes, and perform minor engine part rebuilds and other maintenance on vehicles and equipment. Major engine rebuilding and overhauling tasks are not conducted at COUTES.

3.3.4. Office Trailer.

In 1986, an office trailer (48 feet by 24 feet) was installed south of the former maintenance building. The trailer has three offices, a storage room, a latrine (toilet and sink), and a large room for meetings, training, and breaks.

3.3.5. Utilities.

Drinking water is provided from an onsite well. The well and two pressure tanks are located inside a well house with wood siding and a concrete floor (8 feet by 8 feet). A new well pump was installed in May 2001. Water is stored in the adjacent concrete cistern (20 feet by 20 feet). Sewage treatment is provided onsite with a 1,000-gallon septic tank and a drain field. The septic tank and drain field system was designed to handle domestic wastewater generated by 20 people. It is adequate for daily use by the 18 fulltime COUTES employees and occasional visitors. A vault toilet constructed in 1989 outside the COUTES fence is used by troops that are training at the BTC. Electric power is supplied to the COUTES via overhead and underground lines. The buildings are heated with propane, and tanks are located near each building.

3.4. SITE-SPECIFIC OPERATIONAL HISTORY AND WASTE CHARACTERISTICS OF ENVIRONMENTALLY SIGNIFICANT OPERATIONS.

A photodocumentation log of conditions observed during the SAS field survey is provided in Appendix D. Sixteen operations were identified during the SAS as environmentally significant. Locations are shown in Figure 4, and the following paragraphs describe each operation in detail.

3.4.1. Former Mini-Tank Range.

3.4.1.1. Operational History. Between 1979 and 1989, a small firing range had been located along the south fence line. Its dimensions were 90 feet by 115 feet. It was surrounded on three sides (east, south, and west) by a 9-feet high wood fence constructed of 2-inch by 6-inch boards and on the north side by a retaining wall constructed of wood logs. According to personnel at the COUTES, only clay bullets were fired at the range. The range is no longer used and was removed, possibly when the active COUTES maintenance shop was built.

3.4.1.2. Waste Characteristics. If only clay bullets were fired, metals are not potential contaminants of concern. If regular bullets were used, lead would be the primary contaminant of concern.

3.4.2. Former Septic Tank and Drain Field.

3.4.2.1. Operational History. The original septic tank and drain field system was installed in 1978-79, at the time the former COUTES maintenance shop was built. The septic tank was located 23 feet south of the former shop, and the beginning of the drain field was located 45 feet south of the former maintenance shop. The 1,000-gallon concrete septic tank was connected to a distribution box attached to three parallel drain pipes, each 4 inches in diameter and 50 feet long, spaced 10 feet apart. When the office trailer was added to the COUTES compound in 1986, the former septic tank and drain field were abandoned in place.

3.4.2.2. Waste Characteristics. Only the latrine fixtures and a floor drain in the latrine of the former COUTES maintenance shop were connected to the system. Potential contaminants of concern during active use of the former septic tank and drain field would have been nitrates from wastes and phosphates from soaps.

3.4.3. Active Septic Tank and Drain Field.

3.4.3.1. Operational History. The active septic tank and drain field were built in 1986 when the office trailer was installed. The 1,000-gallon polyethylene septic tank is located 125 feet west of the northwest corner of the office trailer. The water from the septic tank drains

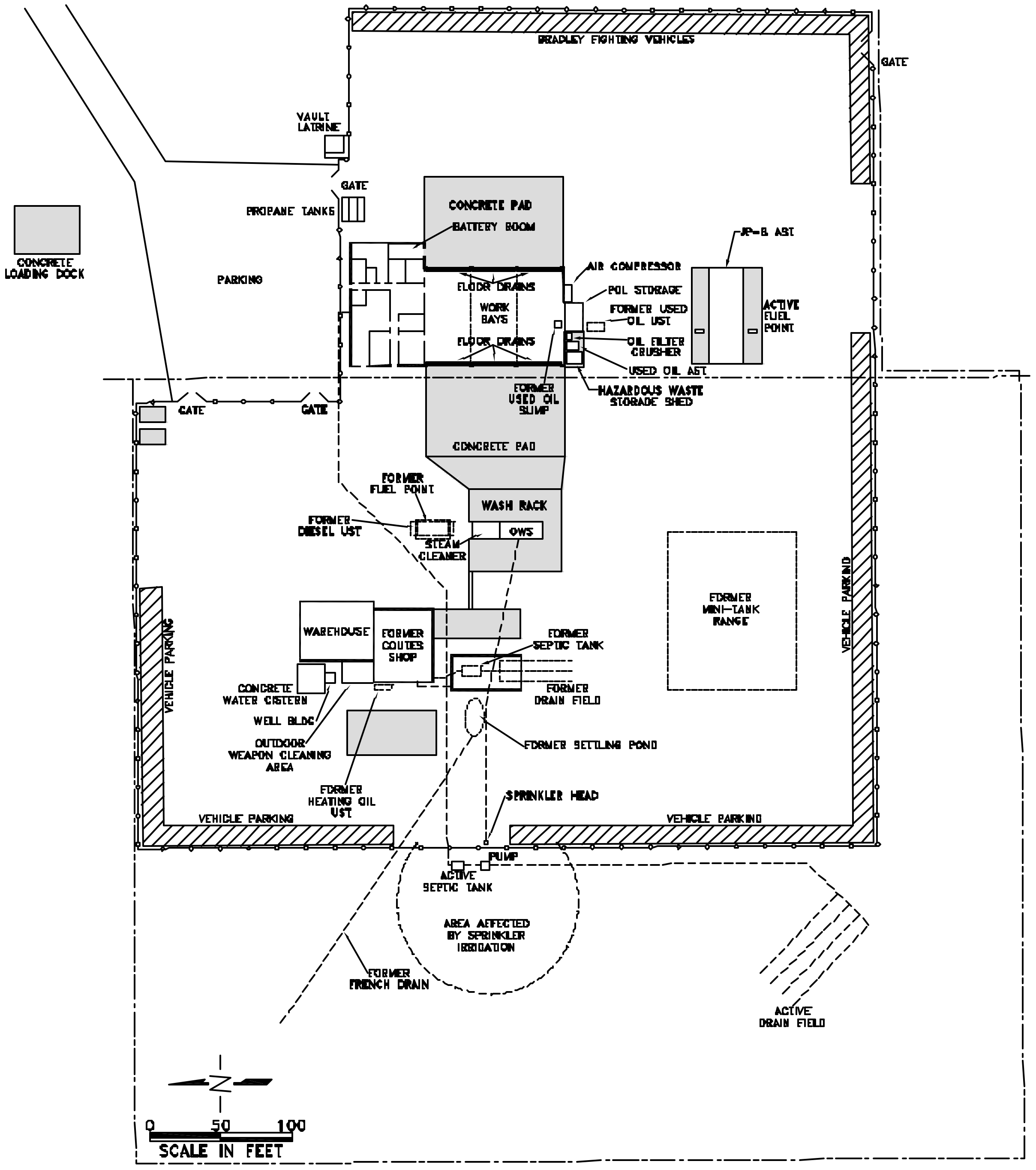

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FIGURE 4.
LOCATIONS OF ENVIRONMENTALLY SIGNIFICANT OPERATIONS
AT THE COUTES, REDMOND, OREGON.

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GCL	38-EH-5048B-02	OR/COUTES/5048BESO

to a lift station and is pumped through approximately 330 feet of 2-inch diameter polyvinyl chloride pipe to a distribution box connected to the drain field. The drain field is located outside the southwest corner of the fenced compound. It consists of four parallel drainpipes, each 4 inches in diameter and 75 feet long, spaced 10 feet apart.

3.4.3.2. Waste Characteristics. The active septic tank and drain field receive domestic wastewater from latrine facilities in the former COUTES maintenance shop, the office trailer, and the active COUTES maintenance shop. Potential contaminants of concern are nitrates from wastes and phosphates from soaps.

3.4.4. Wash Rack Discharge to Former Settling Pond and Former French Drain.

3.4.4.1. Operational History. The wash rack was built in 1978-79, at the same time as the former COUTES maintenance shop. It consisted of a U-shaped area with two concrete wash pads (each 20 feet by 36 feet) separated by 15 feet and connected by a concrete turning pad (30 feet by 55 feet). A steam cleaner was located in the 15-feet space between the two wash pads. Each wash pad sloped to a circular catch basin on one corner, and the catch basins were connected to a central catch basin with a pipe leading to an unlined settling pond (23 feet by 40 feet) located approximately 10 feet west of the former septic tank and drain field. A constructed ditch or French drain led northwest from the settling pond and discharged to a natural ditch area outside the fence (reference 23). Clogging was a frequent problem with the drain system. The settling pond was occasionally dredged and the sediment was stockpiled around the pond's perimeter. The pond and French drain were filled in with gravel when the wash rack treatment system was upgraded in 1986 with an OWS and sprinkler irrigation.

3.4.4.2. Waste Characteristics. Potential contaminants of concern in the sediments and soil of the former settling pond and French drain are total petroleum hydrocarbons (TPH) from oils and greases, volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) from various solvents, and metals from vehicle paint particles. In November 1994, Century West Engineering Corporation (CWEC) excavated 10 test pits and collected soil samples that were analyzed for TPH, VOCs, SVOCs, polychlorinated biphenyls (PCBs), and metals [via the toxicity characteristic leaching procedure (TCLP)]. Figure 5 shows the locations of the test pits and soil samples. Test Pits 1 and 3 were excavated near the edge of the former settling pond, Test Pit 2 was excavated in the center of the former settling pond and at the beginning of the former ditch or French drain, and Test Pits 4, 5, and 6 were excavated along the former ditch or French drain. Test Pit 10 was used to determine background concentrations. Soil sample number 6 from Test Pit 2 in the former settling pond contained detectable TPH (diesel range), barium, and cadmium. Soil samples 5, 7, 11, and 15 from the test pits in the French drain contained detectable concentrations of tetrachloroethene (PCE). All concentrations were below ORDEQ cleanup levels (reference 23).

3.4.5. Wash Rack Discharge to Former OWS and Sprinkler.

3.4.5.1. Operational History. In 1986, a baffled concrete tank OWS was installed between the two wash rack pads. Water from the OWS was pumped to a partially rotating sprinkler head mounted on a pole along the western fence line. The water sprays in an arc,

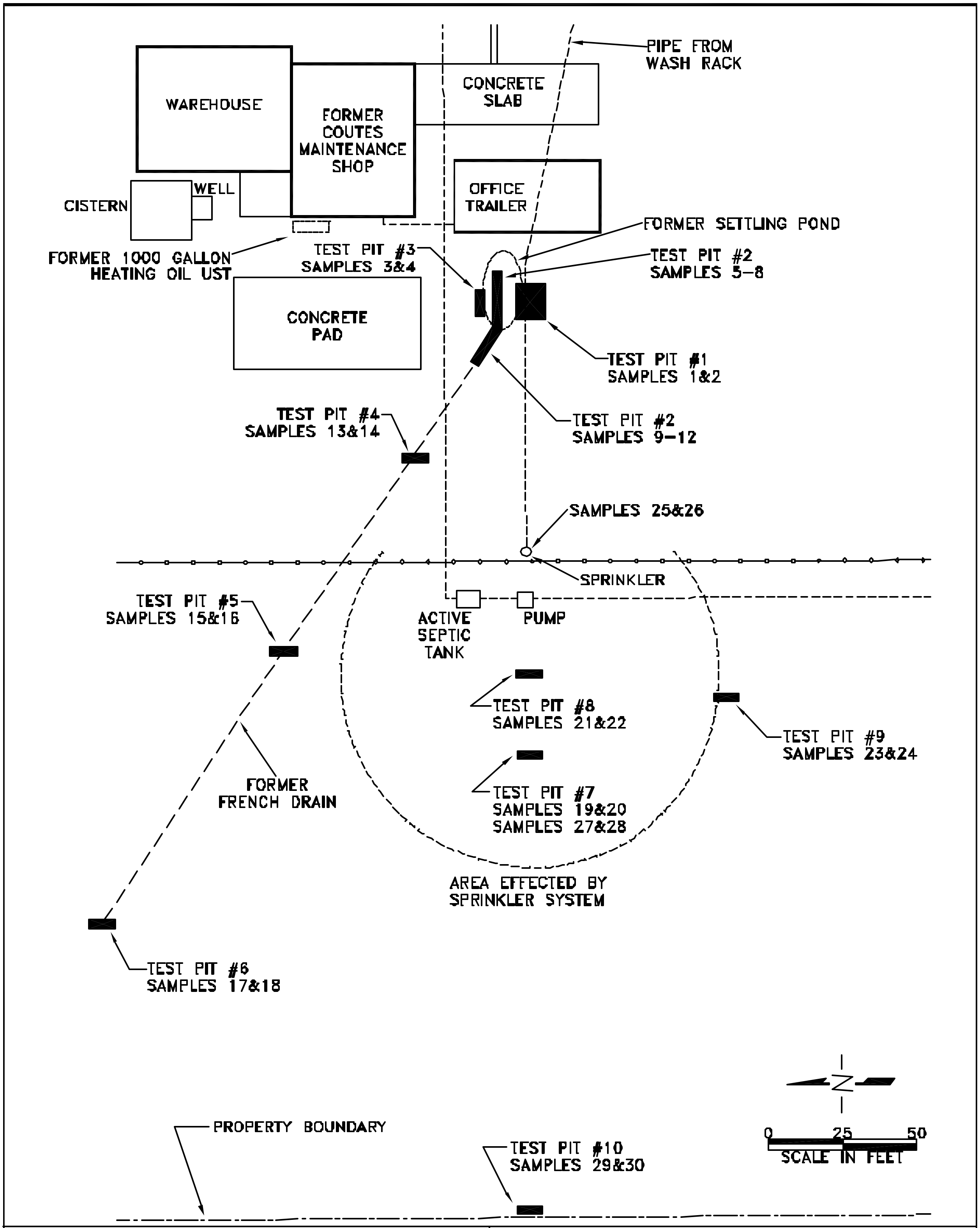

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FIGURE 5.
LOCATIONS OF TEST PITS AND SOIL SAMPLES
COLLECTED IN NOVEMBER 1994 BY
CENTURY WEST ENGINEERING CORPORATION.

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falling on the ground outside the fence but still within the lease boundary. The baffled tank OWS was upgraded in 1995 with a filtration system.

3.4.5.2. Waste Characteristics. The potential contaminants of concern passing through the OWS and sprayed on the ground are TPH from oils and greases and VOCs and SVOCs from various solvents. It is less likely that metals particles were pumped from the OWS to the sprinkler. CWEC's November 1994 investigation also included excavating and collecting soil samples from three test pits (7, 8, and 9) inside the sprinkler irrigation area and two soil samples adjacent to the sprinkler head. Figure 5 shows the locations of the test pits and soil samples. The samples were analyzed for TPH, VOCs, SVOCs, PCBs, and TCLP metals. No TPH, SVOCs, or PCBs were detected in any of the samples. PCE was detected in samples 19, 23, and 25; and several metals were detected in all of the samples. All concentrations were below ORDEQ cleanup levels (reference 23).

3.4.6. Wash Rack Discharge to Upgraded OWS, Filter Unit, and Sprinkler.

3.4.6.1. Operational History. The existing baffled tank OWS was retrofitted and upgraded with a filtration system in January 1995. The entire unit was enclosed in a block building (12 feet by 20 feet) connected to the existing steam cleaner building (12 feet by 20 feet). Wastewater from the wash rack, the trench floor drains in the active COUTES maintenance shop bays, and the drains from the concrete pads at the active fuel dispensing point enter the 2,318-gallon oily water tank. The wastewater is pumped from the tank to the filter unit. Oily sludge separated in the filter unit is pumped into a holding tank suspended over the oily water tank. Clean treated water from the filter unit is pumped to the 972-gallon clean water tank and out to the sprinkler depending on the tank's water level. Float switch control systems activate the pumps and control the water levels in both tanks.

3.4.6.2. Waste Characteristics. The potential contaminant of concern is TPH. The new wastewater treatment system for the wash rack and other drains should be very effective in removing contaminants. However, small concentrations of TPH may pass through the OWS if certain types of detergents are used at the wash rack or on the maintenance bay floors.

3.4.7. Trench Floor Drains in Active COUTES Maintenance Shop Bays.

3.4.7.1. Operational History. Trench floor drains are located at the six bay doors of the active COUTES maintenance shop. The trench drains are connected to the OWS at the wash rack. Grit that accumulates in the drains and in the sump at the end of the drains is removed approximately twice a year, put in plastic bags, and disposed in the solid waste dumpster. Six small flammable storage cabinets are located in the maintenance bays and are used to store containers of grease, cleaners, thinners, paints, and adhesives. The cabinets are double-walled metal storage containers designed to contain spills or leaks of the materials stored within them. The potential for release of a hazardous material from the cabinets is low. If a spill occurred outside of the cabinet, the released materials would flow over the shop floor and eventually reach the floor drains if not first cleaned up. Six parts washers using Zep Dyna 143[TM] non-hazardous parts washer solvent are also located in the maintenance bays. One aqueous parts washer is

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[TM] Zep Dyna 143 is a trademark of National Service Industries, Inc., Atlanta, Georgia.

located in bay 5. If a spill occurred from any one of the parts washers, it would eventually reach the floor drains if not first cleaned up.

3.4.7.2. Waste Characteristics. The potential contaminants of concern are TPH and VOCs. No spills that occurred in the maintenance bays had reached the floor drains. Oil sweep was stored nearby for spills.

3.4.8. Former Fuel Dispensing Point with Underground Storage Tank (UST).

3.4.8.1. Operational History. A diesel fuel dispensing point had been located 14 feet north of the north edge of the wash rack. Constructed between 1978 and 1986, the fuel point had consisted of one fuel pump and dispenser on one island, one UST, and associated underground piping. The 7,000-gallon diesel UST had been permitted by ORDEQ under facility number 606 and permit number BKBHH. On 9 April 1997, the UST was decommissioned (removed) by Seminole Environmental, Inc., under contract to OMD. Seminole removed the pump island, excavated and removed the tank and underground piping, collected two soil samples from the north and south ends of the floor of the excavation, and backfilled and compacted the area. Ground water was not encountered. The tank and piping were cleaned and recycled as scrap metal through Swift & McCormick Metal Processors, Inc., in Redmond. The liquid and sludge removed from the tank were recycled through Central Waste Oil Haulers in Bend. Oregon Analytical Laboratory in West Linn, OR, screened the two soil samples for TPH using ORDEQ's method for hydrocarbon identification (HCID). No fuel constituents were detected in the sample from beneath the north end of the UST; however, diesel was identified in the sample from beneath the south end of the UST. The sample was subsequently analyzed using EPA method 418.1M, and TPH was detected at a concentration of 85 milligrams per kilogram (mg/kg) (reference 24). The detected concentration was less than the ORDEQ Level 1 cleanup standard of 100 mg/kg for diesel or heavier petroleum (reference 25). As required, the OMD Environmental Office submitted the UST decommissioning forms and report to ORDEQ for review (reference 26). The ORDEQ acknowledged and approved the decommissioning and removal of the UST (reference 27).

3.4.8.2. Waste Characteristics. TPH, the only potential contaminant of concern, was detected in one of the two samples, but the concentration was below the ORDEQ Level 1 cleanup standard (references 24 and 25).

3.4.9. Active Fuel Dispensing Point with Aboveground Storage Tank (AST).

3.4.9.1. Operational History. The active JP-8 fuel dispensing point with a 12,000-gallon AST was installed south of the active COUTES maintenance shop in 1997. The vaulted AST consists of a steel inner tank surrounded by a minimum of 6 inches of lightweight insular concrete enclosed by a steel outer shell with an interstitial monitoring tube. The pumps are equipped with automatic shut-off valves, and trucks are chocked during fueling operations. Two fire extinguishers are located on the west end of the AST. The closest spill response material is located on the west side of the fuel point. The kit includes an overpack drum and absorbent materials. The AST is located on a concrete pad and is surrounded by 4-feet high concrete posts. The concrete pads on either side of the AST are slightly sloped to central drains that lead to the OWS at the wash rack. Trucks park on the concrete pads during fueling operations. The potential for release as a result of AST failure is remote. A release during refueling operations would flow first across the concrete pad to the drain. If the capacity of the OWS were exceeded, the spilled material would flow onto the gravel parking area and towards the northwest corner of the facility (references 28 and 29).

3.4.9.2. Waste Characteristics. The potential contaminant of concern is TPH.

3.4.10. Former Used Oil Sump and UST.

3.4.10.1. Operational History. When the active COUTES maintenance shop was constructed in 1989-1990, a sump and UST were installed to collect used oil. The used oil sump is still located inside the active COUTES maintenance shop next to the POL room door. The port to the sump is covered with a metal plate, and the sump is covered with a piece of plywood. The sump had been connected to a 1,030-gallon UST located outside the maintenance shop, approximately 20 feet from the south wall and adjacent to the south wall of the POL storage room. The UST, which was not required to be registered with the ORDEQ, was constructed of asphalt-covered steel and had been installed inside a prefabricated vault that provided secondary containment. On 9 April 1997, in conjunction with the removal of the diesel UST at the former fuel dispensing point (paragraph 3.4.8.), the former used oil UST and vault were removed by Seminole Environmental, Inc., under contract to OMD. Seminole excavated and removed the tank and underground piping, collected two soil samples from the east and west ends of the floor of the excavation, and backfilled and compacted the area. Ground water was not encountered. The tank and piping were cleaned and recycled as scrap metal through Swift & McCormick Metal Processors, Inc., in Redmond. The liquid and sludge removed from the tank were recycled through Central Waste Oil Haulers in Bend. Oregon Analytical Laboratory in West Linn, OR, screened the two soil samples using ORDEQ's TPH-HCID method. No fuel constituents were detected in either of the samples (reference 24).

3.4.10.2. Waste Characteristics. The potential contaminants of concern were TPH and heavy metals. However, TPH was not detected in the soil samples collected during removal of the UST (reference 24).

3.4.11. Active Used Oil AST.

3.4.11.1. Operational History. All used oil generated at the COUTES is now stored in a 500-gallon AST located on the concrete pad outside the POL room on the south end of the active COUTES maintenance shop. The AST sits under a three wall metal structure, with a roof. The AST has built-in secondary containment, is interstitially vented, and is equipped with a leak detection system. The used oil is manually deposited into the AST via an opening in the top. Used oil is collected for recycling at an offsite facility (reference 28).

3.4.11.2. Waste Characteristics. Possibility for spills exists when transporting used oil from the shop to the AST. There was no evidence of leakage or spills on the concrete pad surrounding the AST, and no release is expected. However, if a release had occurred or were to occur from the AST, the contaminants of concern would be TPH and metals.

3.4.12. Former Heating Oil UST.

3.4.12.1. Operational History. A 1,000-gallon UST had been located outside the mechanical room on the east side of the former COUTES maintenance shop. It had been used to store heating oil for the furnace in the shop and was not required to be registered with the ORDEQ. On 9 April 1997, in conjunction with the removal of the diesel UST at the former fuel dispensing point (paragraph 3.4.8.), the former heating oil UST was removed by Seminole Environmental, Inc., under contract to OMD. Seminole excavated and removed the tank and underground piping, collected two soil samples from the north and south ends of the floor of the excavation, and backfilled and compacted the area. Ground water was not encountered. The tank and piping were cleaned and recycled as scrap metal through Swift & McCormick Metal Processors, Inc., in Redmond. The liquid and sludge removed from the tank were recycled through Central Waste Oil Haulers in Bend. Oregon Analytical Laboratory in West Linn, OR, screened the two soil samples using ORDEQ's TPH-HCID method. No fuel constituents were detected in either of the samples (reference 24). The building is now heated with a furnace that uses propane, and the propane tank is located in approximately the same location as the former heating oil UST.

3.4.12.2. Waste Characteristics. The potential contaminant of concern was TPH. However, no contaminants were detected in the soil samples collected during removal of the UST (reference 24).

3.4.13. Outdoor Weapon Cleaning Area.

3.4.13.1. Operational History. A weapon cleaning area is located under an open-air roof outside the door on the east side of the former COUTES maintenance shop. Two covered parts washers are located on a concrete pad, and three wooden worktables are located over the gravel. The COUTES well is located less than 10 feet away and might be vulnerable to spills and discharges from the weapon cleaning area. Although the roof helps to protect the area from precipitation that could carry any contamination to deeper soils, spills and drips from the parts washers may contaminate the surface soil beneath the gravel. Constructing a bermed concrete pad for the area would prevent any discharges from reaching soil or ground water.

3.4.13.2. Waste Characteristics. The potential contaminants of concern are TPH, VOCs, and metals.

3.4.14. Oil Filter Crusher.

3.4.14.1. Operational History. An OBERG™ oil filter crusher model P200-L is located outside the active COUTES maintenance shop, on a concrete pad with the used oil AST and the hazardous waste storage shed. Oil filters are drained over a barrel inside the shop, and then are brought outside to be crushed. A barrel under the crusher stores the crushed filters until enough are collected to recycle or dispose.

™ OBERG is a registered trademark of OBERG International, Marysville, WA.

3.4.14.2. Waste Characteristics. Potential contaminants of concern with used oil are TPH and heavy metals. However, there was no evidence of leakage or spills on the surrounding concrete pad.

3.4.15. Hazardous Waste Storage Shed.

3.4.15.1. Operational History. A hazardous waste storage shed is located outside the active COUTES maintenance shop, on a concrete pad with the oil filter crusher and the used oil AST. The portable white metal shed has built-in secondary containment, a single storage bay, and dual doors. It contains an aerosol can puncturer and drums for waste antifreeze, punctured cans, and contaminated fuel.

3.4.15.2. Waste Characteristics. The hazardous waste turn-in shed has built-in secondary containment that prevents spills from reaching the ground. Possibility for spills exists when transporting materials and waste, but there was no evidence of leakage or spills on the concrete pad.

3.4.16. Vehicle Parking Yard.

3.4.16.1. Operational History. Since the COUTES began operating, military vehicles have been parked on the gravel surface around the inside perimeter of the COUTES fence. The perimeter parking is covered to the fence line with red cinder gravel trucked from a local source. M1 tanks, Bradley fighting vehicles, and four 2,500-gallon Heavy Equipment Mobility Tactical Trucks (HEMTTs) are parked on the east side of the facility. The HEMTTs typically store less than 250 gallons of residual fuel when parked at the facility. Additional vehicles and miscellaneous equipment are parked along the edge of the facility on the south, west and northwest sides. A 1,200-gallon tank and pump unit (TPU) is parked on the southwest edge of the facility. The TPU typically stores less than 50 gallons in each 600-gallon pod when parked at the facility. Neither the HEMTTs nor the TPU are double walled or parked over secondary containment. Any release would seep into the ground below the graveled surface. Bermed concrete pads will be constructed in the future to store the HEMTTs and TPU and prevent any release from contaminating the ground (reference 28).

3.4.16.2. Waste Characteristics. The potential contaminant of concern is TPH.

4. GROUND-WATER PATHWAYS AND TARGETS.

4.1. GENERAL GROUND-WATER PATHWAY ANALYSIS.

With the exception of the areas covered by buildings, the COUTES compound is covered with packed gravel over native soil. The Deschutes-Stukel Complex soils have moderately rapid permeability rates, which would enhance infiltration and allow potential contaminants in the soil to reach ground water. However, the arid environment, high evaporation rate, and great depth to ground water decreases the chance of surface or shallow subsurface contaminants reaching the ground water.

4.2. GENERAL GROUND-WATER TARGET ANALYSIS.

4.2.1. Water Wells in 4-mile Radius.

According to the Oregon Water Resources Department (reference 30), there are at least 613 registered water wells (not including monitoring wells, geotechnical borings, or officially abandoned wells) located within a 4-mile radius of the COUTES. Some wells are registered for multiple uses. Only 13 of the wells are registered as community water supplies, but 561 wells are registered for domestic/private water supply. Well locations are registered according to township, range, section, quarter section, and quarter-quarter section; however, all well locations are not noted to the quarter-quarter section level. Due to the very large number of wells and the lack of exact location information for each well, a map showing well locations within the 4-mile radius is not feasible. Appendix E provides information for each well, and Table 3 provides consolidated information.

Table 3. List of Registered Water Wells within 4-Mile Radius of COUTES.

WELL USE	T15S, R13E Sections 1, 2, 3, 4, 5, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 32, 33, 34, 35, 36	T15S, R14E Sections 5, 6, 7, 8, 16, 17, 18, 19, 20, 21, 28, 29, 30, 31, 32	T16S, R13E Sections 1, 2, 3, 4, 5, 9, 10, 11, 12	T16S, R14E Sections 5, 6, 7	T14S R13E Sections 33, 34, 35, 36	T14S R14E Section 31	TOTALS
Community	12	1	0	0	0	0	13
Domestic/Private	316	21	3	0	221	0	561
Industrial	5	0	0	0	0	0	5
Irrigation	7	0	0	0	2	0	9
Unlabeled	18	0	0	0	5	0	23
TOTALS	358	24	3	0	228	0	613

Source: reference 30.

4.2.2. COUTES Water Supply Well.

The water supply well provides water for all activities at the COUTES. A 10-inch diameter hole was drilled to a total depth of 425 feet during 30 October 1978 to 16 February 1979. The well was cased with 6-inch diameter welded casing and screened with 6-inch diameter 10-slot screen from 378 to 420 feet. The water-bearing zone was found at 390 feet, and the static water level was 375 feet on 20 February 1979. The most recent water quality samples were collected on 16 March 2001 from the sink tap in the office trailer. The samples were analyzed for E. coli, total coliform, and nitrate, and the results were less than EPA maximum contaminant levels (MCLs). In August 1998, samples were collected for E. coli, total coliform, nitrate, copper, and lead, and the results were also less than EPA MCLs or MCL goals. Copies of the well log and the water quality reports are contained in Appendix C.

4.2.3. Nearest Water Well.

With the exception of the COUTES well, no wells are located within the same section as the COUTES (section 23 of T15S and R13E). Only seven registered water wells are located in any of the adjoining sections (13, 14, 15, 22, 24, 25, 26, and 27). Three of the wells are owned by the city of Redmond and are registered for community use. The other four wells are privately owned and are registered for domestic/private use. Exact location and current status for the wells is unavailable.

4.2.4. City of Redmond's Water Supply System.

The city of Redmond supplies drinking water and fire protection water from five operational wells to 13,705 customers at approximately 5,000 connections within the urban growth boundary. The depths of the wells range from 300 feet to 800 feet below ground surface, and the static water level is at an elevation of approximately 2,700 feet above mean sea level. Each well pumps directly into the distribution system, and chlorination is provided at the well.

4.2.5. Wellhead Protection Areas.

The city of Redmond has not instituted a wellhead protection program.

4.3. SITE-SPECIFIC GROUND-WATER PATHWAYS.

There have been no documented releases of hazardous substances to the ground water from any of the described environmentally significant operations. Hazardous substances (TPH-diesel, PCE, and metals) have been detected at low concentrations in the subsurface soil at the sprinkler irrigation area and the former settling pond and French drain (reference 23). However, the low levels of contaminants would not likely affect the deep ground water. Due to its very close proximity to the COUTES well, the outdoor weapon cleaning area is a potential source of ground-water contamination. The potential is very low because of the great depth to ground water and the small amounts of hazardous substances used. However, construction of a bermed concrete pad for the area would prevent any releases from reaching the soil or ground water.

5. SURFACE WATER PATHWAYS AND TARGETS.

5.1. GENERAL SURFACE WATER PATHWAY ANALYSIS.

Nearly all of the precipitation falling on the COUTES quickly evaporates due to the dry atmosphere or percolates into the surface soil because the Deschutes-Stukel Complex soils have moderately rapid permeability rates. Very little surface runoff actually occurs, but rapid snowmelt or extremely heavy thunderstorms may result in a small amount of runoff and flow in natural ditches. Surface runoff may become contaminated if it comes into contact with contaminated surface soil or sediment. Tactical vehicles without drip pans are parked on the gravel, but most of the areas where hazardous substances are stored or are used are inside buildings or sheds.

5.2. GENERAL SURFACE WATER TARGET ANALYSIS.

There are no known drinking water intakes (targets) for at least 15 downstream miles from the COUTES.

5.3. SITE-SPECIFIC SURFACE WATER PATHWAYS.

There have been no releases of hazardous substances directly to surface water or that would reach surface water from any of the described environmentally significant operations.

6. SOIL EXPOSURE PATHWAYS AND TARGETS.

6.1. GENERAL SOIL EXPOSURE PATHWAY AND TARGET ANALYSIS.

Soils at the COUTES consist primarily of sandy loam formed from loess and ash. A portion of the site is covered with buildings and concrete pads, and compacted gravel covers the remaining area. The potential for entrainment of surface soil into the air is high. There are 18 fulltime employees at the COUTES. Personnel work 9 hours per day, 4 to 5 days per week. Nine personnel are at the COUTES on each of two drill weekends per month. There are no residents onsite or within 200 feet of the site. No schools or childcare facilities are located onsite or within 200 feet of the site.

6.2. SITE-SPECIFIC SOIL EXPOSURE PATHWAYS.

Hazardous substances (TPH-diesel, PCE, and metals) have been detected at low concentrations in the subsurface soil at the sprinkler irrigation area and the former settling pond and French drain (reference 23). No other releases to soil have been documented nor was evidence of staining visually observed. No release is suspected of hazardous substances to the soil from any of the other described environmentally significant operations.

7. AIR PATHWAYS AND TARGETS.

Air quality is generally good at the COUTES and in the Redmond area. The area has not been designated as a non-attainment area for any of the five air pollutants (particulate matter, carbon monoxide, ozone, sulfur dioxide, or nitrogen oxides (reference 31). The nearest ORDEQ air quality surveillance network stations are located in Bend at Kenwood School (continuous particulate monitor), at NE 3rd Street (carbon monoxide), at the intersection of 8th and Newport Streets (PM_{10} and $PM_{2.5}$), and at Deschutes Market Road (wind and temperature) (reference 32). None of the described environmentally significant operations at COUTES are likely to release hazardous substances to the air.

8. CONCLUSIONS.

8.1. PATHWAYS AND TARGETS.

8.1.1. General.

For a pathway to be complete, there must be a source with a release of hazardous constituents to some environmental media (e.g. soil, air, water, sediment), a transport mechanism between the media and an exposure point (e.g. indoor air, outside air, soil in yard, water in well), and exposure routes (e.g. oral, inhalation, dermal) between the exposure point and a human receptor. If any of these steps do not exist, then the pathway is not complete.

8.1.2. Ground Water.

The ground-water pathway is not complete from a source to a target. There were no documented releases to ground water. Although the wash rack and its associated former and active treatment systems are potential sources of subsurface soil contamination, upgrades and discontinuation of use have reduced the potential impact to ground water. Although a large number of active drinking water wells (including the COUTES well) exist within the area, none would be likely to be affected by operations at the COUTES.

8.1.3. Surface Water.

The surface water pathway is not complete from a source to a target because there is no surface water flow and there are no drinking water intakes downstream from the COUTES.

8.1.4. Soil and Air.

Most of the operations at the COUTES are inside buildings and therefore are not likely to affect surface soil or air quality. Although releases of hazardous substances to soil have been documented from the former settling pond and French drain, the system is no longer used. The potential for soil entrainment into the air is high. Although fine particles from the gravel-covered areas could become airborne, no hazardous constituents were present. There are no residences, schools, or childcare facilities within 200 feet of the site.

8.2. POTENTIAL SOURCE AREAS.

The wash rack and its associated treatment systems (former settling pond, French drain, and sprinkler irrigation) have released low concentrations of TPH-diesel, PCE, and metals into the shallow subsurface soil. However, due to discontinuation of use, upgrading of the OWS, low concentrations, and the lack of targets, additional sampling is not necessary or recommended at the potential source.

8.3. PREVENTIVE MEASURES.

Although sampling is not recommended at any of the environmentally significant operations, some measures should be taken to prevent regulatory action, adverse effects to human health, or environmental contamination. The COUTES well is located less than 10 feet from the outdoor weapon cleaning area, making it vulnerable to spills and discharges. Although the roof helps to protect the area from precipitation that could carry any contamination to deeper soils, spills and drips from the parts washers may contaminate the surface soil beneath the gravel. A bermed concrete pad for the area would prevent any discharges from reaching soil or ground water.

9. RECOMMENDATIONS.

9.1. Environmental sampling is not recommended at any of the described operations.

9.2. Construct a concrete pad with a berm for the outdoor weapon cleaning area.

Kim M Fleischman
KIM M. FLEISCHMANN
Environmental Scientist

REVIEWED:

John W. Bauer
for BARRETT E. BORRY, P.G.
Chief
Restoration Section

APPROVED:

John W. Bauer
JOHN W. BAUER, P.G.
Program Manager
Ground Water and Solid Waste

APPENDIX A

REFERENCES

1. Final Environmental Assessment, Fielding the Bradley Fighting Vehicle and Cavalry Fighting Vehicle and Other Proposed Federal Activities at the Central Oregon Training Site by the Oregon Army National Guard, March 1995; prepared by CH2M Hill for the Oregon Military Department.

2. Internet page, Oregon Department of Geology and Minerals Industries, Learn more about Oregon's geology, http://www.oregongeology.com/learnmore/learnmore.htm.

3. Internet page, Oregon Climate Service, http://www.ocs.orst.edu.

4. Internet page, City of Redmond, http://www.redmond.or.us/.

5. Internet page, The Weather Channel, http://www.weather.com/weather/climatology/USOR0284.

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7. Soil Survey of Upper Deschutes River Area, Oregon, Parts of Jefferson, Deschutes and Klamath Counties, March 1992; published by the U.S. Department of Agriculture, Soil Conservation Service.

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9. Lyman, R. Lee, Michael A. Gallagher, Clayton G. Lebow, and Mary Kathryn Weber, 1983. *Cultural Resource Reconnaissance in the Redmond Training Area, Central Oregon*; prepared by Oregon State University, Department of Anthropology, for the Oregon Military Department and the Bureau of Land Management, Prineville District.

10. Internet page, Deschutes and Ochoco National Forests, Newberry National Volcanic Monument, http://www.fs.fed.us/r6/centraloregon/index.html.

11. Site Investigation Report, COUTES Site, Oregon Military Department, Redmond, Oregon 97756, January 1995; prepared by Century West Engineering Corporation for the Oregon Military Department.

12. Internet page, Oregon Water Resources Department, http://www.wrd.state.or.us.

13. Oregon Natural Heritage Program, February 2001. *Rare, Threatened, and Endangered Plants and Animals of Oregon*, PDF available at http://www.abi.org/nhp/us/or/.

14. 2000-2001 Redmond Visitor's Guide, published by the Redmond Spokesman.

15. Lease agreement AL-10, between the Redmond Airport Commission, landlord, and the Military Department of the State of Oregon, tenant, 28 June 1973.

16. Letter from City of Redmond to Major Dan W. Vawter, Facilities Management Officer, Oregon Military Department, 22 September 1986, subject: March 19, 1986, Redmond Airport Commission to Military Department of the State of Oregon, Addendum to Lease Agreement (AL-10).

17. Lease agreement, between the City of Redmond, landlord, and the Military Department of the State of Oregon, tenant, 13 January 1987.

18. Bargain and Sale Deed recorded 23 November 1987, Deschutes County, Oregon, File 87-24078.

19. Internet page, Envirofacts Warehouse, http://www.epa.gov/enviro/html/multisystem_query_java.html.

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21. Internet page, Oregon Department of Environmental Quality, Water Quality Division, Wastewater Permits Database, http://www.deq.state.or.us/wq/SISData/FacilityHome.asp.

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23. Site Investigation Report, COUTES Site, Oregon Military Department, Redmond, Oregon 97756, January 1995; prepared by Century West Engineering Corporation for the Oregon Military Department.

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25. Hood, Robert, and McCulloch, Laurie, October 2001. *Fact Sheet, TPH Soil Testing at Underground Storage Tank Sites*. Oregon Department of Environmental Quality, Land Quality Division, Underground Storage Tank Program.

---

26. Memorandum, Oregon Military Department, AGI-ENV, 29 April 1998, subject: UST Decommissioning.

27. Letter, Oregon Department of Environmental Quality, 21 October 1998, subject: UST Permit Status.
28. Integrated Contingency Plan, Central Oregon Unit Training and Equipment Site, Redmond, Oregon; prepared by Science Applications International Corporation for Oregon Military Department, February 2001.

29. Permit Approval, Flammable and Combustible Liquid Above Ground Tanks, issued on 28 August 1997 to OMD by the Office of the State Fire Marshal, permit number FCL 97-025.

30. Internet page, Oregon Water Resources Department, http://www.wrd.state.or.us.

31. Internet page, Oregon Department of Environmental Quality, Air Quality Non-Attainment Areas in Oregon, http://www.deq.state.or.us/aq/aqplanning/nonattainment.htm.

32. Oregon Department of Environmental Quality, Air Quality Division, 2000. *1999-2000 Oregon Air Quality Data Summaries*, PDF available at http://www.deq.state.or.us/aq/forms/annual_reports.htm.

APPENDIX B

PERSONNEL CONTACTED

1. Mr. Gerald Elliott, Chief, Environmental Office, Oregon Army National Guard (ORARNG), Oregon Military Department (OMD).

2. Mr. Scott Stuemke, Cultural Resources Manager, ORARNG, OMD.

3. MAJ Nancy Borschowa, Environmental Specialist, ORARNG, OMD.

4. CW3 Jim Morrison, General Foreman, Central Oregon Unit Training and Equipment Site (COUTES), ORARNG.

5. Mr. Vince Anderson, Facilities Maintenance, COUTES, ORARNG.

APPENDIX C

WELL LOG AND WATER QUALITY REPORTS FOR THE COUTES DRINKING WATER WELL

NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report are to be filed with the
WATER RESOURCES DEPARTMENT,
SALEM, OREGON 97310
within 30 days from the date of well completion.

RECEIVED
MAY 8 1979
WATER RESOURCES DEPT.
SALEM, OREGON

WATER WELL REPORT
STATE OF OREGON
(Please type or print)
(Do not write above this line)

State Well No. 15S/13E-23
State Permit No.

(1) OWNER:
Name Military Dept., State of Oregon
Address 2150 Fairgrounds Rd., N.E.
Salem, Oregon 97303

(2) TYPE OF WORK (check):
New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:
Rotary ☒ Driven ☐
Cable ☒ Jetted ☐
Dug ☐ Bored ☐

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☒

(5) CASING INSTALLED:
Threaded ☐ Welded ☒
6 " Diam. from +2 ft. to 362 ft. Gage .250
" Diam. from ft. to ft. Gage
" Diam. from ft. to ft. Gage

(6) PERFORATIONS:
Perforated? ☐ Yes ☒ No.
Type of perforator used
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS:
Well screen installed? ☒ Yes ☐ No
Manufacturer's Name Johnson
Type Telescopic Model No. 10 slot
Diam. 6" Slot size 10 Set from 378 ft. to 420 ft.
Diam. Slot size Set from ft. to ft.

(8) WELL TESTS:
Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? Contractor
Yield: 30 gal./min. with 0 ft. drawdown after 1 hrs.
" " " "
" " " "
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m.
Temperature of water 53 Depth artesian flow encountered ft.

(9) CONSTRUCTION:
Well seal—Material used cement
Well sealed from land surface to 25 ft.
Diameter of well bore to bottom of seal 10 in.
Diameter of well bore below seal 8 in.
Number of sacks of cement used in well seal 16 sacks
How was cement grout placed? pressure grout

Was a drive shoe used? ☐ Yes ☒ No Plugs Size: location ft.
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? depth of strata
Method of sealing strata off
Was well gravel packed? ☐ Yes ☒ No Size of gravel:
Gravel placed from ft. to ft.

(10) LOCATION OF WELL:
County Deschutes Driller's well number
¼ N½ ¼ Section 23 T. 15S R. 13E. W.M.
Bearing and distance from section or subdivision corner

(11) WATER LEVEL: Completed well.
Depth at which water was first found 390 ft.
Static level 375 ft. below land surface. Date 2-20-79
Artesian pressure lbs. per square inch. Date

(12) WELL LOG:
Diameter of well below casing 8"
Depth drilled 425 ft. Depth of completed well 420 ft.

Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level and indicate principal water-bearing strata.

MATERIAL	From	To	SWL
Top-Soil	0	4	
Lava	4	107	
Brown Conglom.	107	113	
Lava	113	143	
Brown Sandstone Conglom.	143	154	
Lava	154	200	
Broken Lava & Crevices	200	210	
Lava	210	215	
Brown Conglom.	215	224	
Lava	224	283	
Brown Sandstone	283	320	
Black Sand	320	350	
Brown Sandstone Conglom.	350	390	
Black Sand, Water-Bearing	390	425	

Work started 10-30 1978 Completed 2-16 1979
Date well drilling machine moved off of well 2-28 1979

Drilling Machine Operator's Certification:
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] William D. [illegible] (Drilling Machine Operator) Date 5-3 1979
Drilling Machine Operator's License No. 803

Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Name Orvail Buckner Well Drilling, Inc. (Person, firm or corporation) (Type or print)
Address 1686 N.E. Negus Way, Redmond, Oregon 97756
[Signed] (Water Well Contractor)
C-2
Contractor's License No. 608 Date 5-3-79 19

(USE ADDITIONAL SHEETS IF NECESSARY)

Report For: 980826CU Project Name: Coutes Project No: None Provided 09/02/98 10:32

Enter Public Water System ID# 05957 Coutes	MICROBIOLOGICAL ANALYSIS PUBLIC WATER SUPPLIES DRINKING WATER PROGRAM	Coffey Laboratories, Inc. 12423 NE Whitaker Way Portland, OR 97230 Phone:(503) 254-1794
Collection Information: Date: 08/26/98 Time: 0935 Collected by: Albert Phillips Type of Sample: Routine Sample Point: 2899 E. Hwy 126-Redmond Kitchen	**Laboratory Results** Total Coliform: **Absent** /100 ml E. coli: Laboratory Result: Date of Initial Positive:	Lab Cert #:917 Lab ID: 980826CU-1 Bottle #: 11 Date/Time Received: 08/28/98 11:10 Received by: DJW Date/Time Analyzed: 08/26/98 11:43
Chlorinated? No mg/L	Test Methods: EPA MMO-MUG	Comments: Central_Oregon
----Report Address---- Albert Phillips Coutes 2899 E. Hwy 126 Redmond, OR 97756-0000	Sample Remarks: OREGONMILI Batch ID: 98090054-1	Analyst: TLG Date: 08/26/98 Reviewed by: TLG Date: 09/02/98

Send Results To: Oregon Health Division, P.O. Box 14350, Portland OR 97214-0350 Phone (503) 731-4381 VAP/atc

Report Date: September 1, 1998
Job Number: 980826AM
PWSID: 05957
PO Number: B04237
Project No: Coutes-Annual Nitrate
Project Name: 2899 E. Hwy 126-Redmond

Albert Phillips
Coutes
2899 E. Hwy 126
Redmond, OR 97756-0000

Sample Information

Laboratory Sample ID	Field Identification	Matrix	Collection Date	Collection Time
980826AM-1	2899 E. Hwy 126-Redmond	Drinking Water	08/26/98	0935

Analytical results are on the following page(s).

Sincerely,

Technical Services

The data submitted in this report is for the sole and exclusive use of the above-named client. All samples associated with the work order will be retained a maximum of 15 days from the report date or until the maximum holding time expires. All results pertain only to samples submitted.

Thank you for allowing Coffey Laboratories to be of service to you. If you have questions or need further assistance, please do not hesitate to call our Customer Services Department.

TS/atc

Analytical Data

Coutes

Job Number: 980826AM
PWSID: 05957
Page Number: 2 of 2

Sample Information

Source ID: A
Sampled At: 2899 E. Hwy 126-Redmond
Date Collected: 08/26/98
Date Received: 08/26/98
Sample Composition: Raw/single/dist.
Lab Sample ID: 980826AM-1

Source Name(s): Well
Sampled By: Kitchen Faucet
Time Collected: 0935
Date Analyzed: 08/26/98

EPA Category: Conventional Parameters

Contaminant	Code	MCL mg/L	Detection Limit	Analysis mg/L	Method	Analyst
Nitrate	1040	10.	0.01	0.23	EPA 300.0	JCS

Maximum contaminant level (MCL) means the maximum allowable level of a contaminant in water delivered to the users of a public water system.

Report Date: September 1, 1998
Job Number: 980827AO
PWSID: 05957
PO Number: B04237
Project No: None Provided
Project Name: Coutes

Albert Phillips
Coutes
2899 E. Hwy 126
Redmond, OR 97756

Sample Information

Laboratory Sample ID	Field Identification	Matrix	Collection Date	Collection Time
980827AO-1	2899 E. Hwy 126-Redmond	Drinking Water	08/27/98	0650

Analytical results are on the following page(s).

Sincerely,

Technical Services

The data submitted in this report is for the sole and exclusive use of the above-named client. All samples associated with the work order will be retained a maximum of 15 days from the report date or until the maximum holding time expires. All results pertain only to samples submitted.

Thank you for allowing Coffey Laboratories to be of service to you. If you have questions or need further assistance, please do not hesitate to call our Customer Services Department.

TS/atc

COPY SENT TO
OREGON STATE HEALTH DIVISION

Analytical Data

Coutes

Job Number: 980827AO
Laboratory ID: OR 00011
PWS ID: 05957
Page Number: 2 of 2

Field Identification	Copper Result EPA 200.7	Lead Result EPA 239.2
2899 E. Hwy 126-Redmond	0.05	ND
Detection Limit	0.02	0.001
EPA Limit	1.3	0.015
EPA Code	1022	1030

ND means none detected at or above the detection limit listed.
Results expressed as mg/L unless otherwise noted.

The EPA recommended maximum contaminant level for lead is zero. Water Purveyors are required to take action if the lead concentration is 0.015 mg/L. For private wells, the maximum contaminant level is 0.02 mg/L
The EPA suggested maximum contaminant level for copper is 1 mg/L. For Water Purveyors, the action level is 1.3 mg/L.

E01-055

Report Date: March 22, 2001
Job Number: A10316A
PWSID: None Provided
PO Number: B-02645
Project No: None Provided
Project Name: Coutes

Mil Dept, State of Oregon
Major Nancy E. Borschowa
PO BOx 14350
Salem, OR 97309-5047

Sample Information

Laboratory Sample ID	Field Identification	Matrix	Collection Date	Collection Time
A10316A-1	Trailer Sink	Drinking Water	03/16/01	0630

Analytical results are on the following page(s).

Sincerely,

Linda

Technical Services

The data submitted in this report is for the sole and exclusive use of the above-named client. All samples associated with the work order will be retained a maximum of 15 days from the report date or until the maximum holding time expires. All results pertain only to samples submitted.

Thank you for allowing Coffey Laboratories to be of service to you. If you have questions or need further assistance, please do not hesitate to call our Customer Services Department.

TS/atc

RECEIVED AGI
2001 MAR 26 A 10:08
MILITARY DEPARTMENT
STATE OF OREGON

Analytical Data

Major Nancy E. Borschowa

Job Number: A10316A
Page Number: 2 of 2

Lab Sample ID: A10316A-1
Field ID: Trailer Sink
Date/Time: 03/16/01 0630
Matrix: Drinking Water

EPA Category: Microbiological

Parameter	Method	Detection Limit	Analytical Result	Units	EPA Limit	EPA Code
E. coli	EPA MMO-MUG	----	Absent	/100 ml	Absent	----
Total Coliform	EPA MMO-MUG	----	Absent	/100 ml	Absent	----

EPA Category: Conventional Parameters

Parameter	Method	Detection Limit	Analytical Result	Units	EPA Limit	EPA Code
Nitrate	SM 4500-NO3D	0.1	1.1	mg/L	10.	1040

APPENDIX D

PHOTODOCUMENTATION LOG OF THE COUTES

LIST OF PHOTOS

APPENDIX E

LIST OF REGISTERED WATER WELLS

LOCATED WITHIN 4-MILE RADIUS OF THE COUTES

TABLE E-1. REGISTERED WATER WELLS IN TOWNSHIP 15 SOUTH AND RANGE 13 EAST, WITHIN 4-MILE RADIUS OF THE COUTES.

Section	Quarter 160	Quarter 40	County Code	Well ID	Completion Date	Total Depth (ft)	Static Water Level (ft)	Well Yield (gal per min)	Community	Domestic/ Private	Industrial	Irrigation
1	NE	SW	DESC	3681	03/02/1989	440	390	10		X		
2			DESC	3683	09/29/1981	430	280	85		X		X
2			DESC	3684	08/28/1981	340	280	25				
2			DESC	3685	04/04/1969	279	254	25		X		
2			DESC	3686	04/05/1968	280	258	15		X		
2			DESC	3687	04/29/1966	289	266	26		X		
3	NE	NE	DESC	393	09/24/1979	300	250	12		X		
3	SW	SE	DESC	394	11/27/1972	328	270	20		X		
3	NE	NW	DESC	984	07/26/1991	315	235	30		X		
3	SE	SE	DESC	3688	10/06/1986	447	330	20		X		
3	SE	SE	DESC	3689	03/07/1983	480	268	300				X
3	NW	NE	DESC	3690	07/30/1979	287	240	12		X		
3			DESC	3691	04/26/1979	295	250	11		X		
3	NW	SE	DESC	3692	01/19/1976	295	270	15				X
3			DESC	3693	04/14/1969	280	248	20		X		
3			DESC	3694	02/18/1966	270	245	15		X		
3	NE	NW	DESC	3695	07/23/1975	210	135	15		X		
3	SE	SE	DESC	3696	08/14/1975	145				X		
3	SE	SE	DESC	3697	01/21/1976	220	180	10		X		
3	NW	NE	DESC	3698	01/14/1977	190	121	16		X		
3	SW	NE	DESC	3699	09/19/1979	300	265	8		X		
3	SW	NE	DESC	3700	06/21/1978	297	264	10		X		
3	SW	SW	DESC	3701	11/22/1976	297	250	10				
3	SE	SW	DESC	3702	03/14/1977	130	45	24		X		
3	NW	SE	DESC	3703	10/26/1978	310	160	10		X		
3	NW	SE	DESC	3704	08/03/1974	290	132	20		X		
3	NE	NE	DESC	3705	03/22/1963	295	277	15		X		
3	SE	NE	DESC	3706	09/01/1967	303	260	20		X		
3	SE	NW	DESC	10101	08/04/1995	270	254	5		X		
3	SE	NW	DESC	50553	09/25/1995	290	254	12		X		
3	NE	NE	DESC	50911	06/04/1997		275			X		
4			DESC	395	03/05/1975	295	227	10		X		
4	NW	SE	DESC	810	03/06/1991	260	228	12		X		
4	SE	NW	DESC	1681	03/17/1993	300	232	22		X		

TABLE E-1. REGISTERED WATER WELLS IN TOWNSHIP 15 SOUTH AND RANGE 13 EAST, WITHIN 4-MILE RADIUS OF THE COUTES.

Section	Quarter 160	Quarter 40	County Code	Well ID	Completion Date	Total Depth (ft)	Static Water Level (ft)	Well Yield (gal per min)	Community	Domestic/ Private	Industrial	Irrigation
4	NE	SE	DESC	3707	11/28/1989	275	255	20		X		
4	SE	NE	DESC	3708	06/22/1989	288	250	20		X		
4			DESC	3709	08/24/1987	257	226	10		X		
4	SE	NW	DESC	3710	04/15/1976	295	225	15		X		
4			DESC	3712	08/01/1969	290	265	15		X		
4			DESC	3713	12/28/1965	458	258	28		X		
4			DESC	3714	11/22/1965	368	75	4		X		
4			DESC	3715	06/20/1963	285	255	12		X		
4	NE	NE	DESC	3716	02/27/1979	295	255	9		X		
4	NE	NE	DESC	3717	07/21/1977	310	242	35		X		
4	NW	NE	DESC	3718	02/24/1977	295	240	15		X		
4	NE	SE	DESC	3719	05/19/1977	309	249	100				
4	SW	NE	DESC	3720	11/19/1976	285	245	20		X		
4	NW	NW	DESC	3721	05/16/1973	290	240	20		X		
4	NE	SW	DESC	3722	06/16/1969	296	225	40	X			
4	NE	SW	DESC	3723	02/04/1972	297	235	17	X			
4	SW	NE	DESC	3724	11/30/1957	320	255	25		X		
4			DESC	3725	02/08/1965	260	230	25		X		
4	NE	SE	DESC	3726	08/21/1965	296	260	35		X		
4	NE	SE	DESC	3727	02/01/1966	288	268	10		X		
4	NW	SE	DESC	3728	05/30/1962	318	248	12		X		
4	SE	NW	DESC	9529	09/25/1994	360	265	15		X		
4	SE	SE	DESC	50414	07/19/1996	325	260	12		X		
4	SE	SE	DESC	50512	08/24/1996	415	260	10		X		
5	NW	SE	DESC	396		0	0			X		
5	SE	SW	DESC	977	07/20/1991	310	250	15		X		
5	NE	NE	DESC	1527	09/25/1992	245	219	12		X		
5	SW	NW	DESC	3729	08/18/1988	221	200	15		X		
5	SW	SW	DESC	3730	02/10/1989	272	240	10		X		
5	SW	SW	DESC	3731	10/26/1987	275	240	15		X		
5	SE	NW	DESC	3732	08/21/1987	150	84	11		X		
5	SE	SE	DESC	3733	08/19/1987	273	220	25		X		
5	NE	NW	DESC	3734	08/22/1987	85	66	10		X		
5	NW	NE	DESC	3735	05/24/1986	70	56	10		X		

TABLE E-1. REGISTERED WATER WELLS IN TOWNSHIP 15 SOUTH AND RANGE 13 EAST, WITHIN 4-MILE RADIUS OF THE COUTES.

Section	Quarter 160	Quarter 40	County Code	Well ID	Completion Date	Total Depth (ft)	Static Water Level (ft)	Well Yield (gal per min)	Community	Domestic/ Private	Industrial	Irrigation
5	SE	NW	DESC	3736	03/31/1984	149	92	20		X		
5	SE	SE	DESC	3737	01/11/1983	380	230	15		X		
5	SE	SE	DESC	3738	10/07/1982	305	230	15		X		
5	SE	SE	DESC	3739	07/07/1982	320	230	15		X		
5	NW	NW	DESC	3740	04/19/1982	226	176			X		
5	SW	SW	DESC	3741	11/12/1980	250	228	12		X		
5	SW	SE	DESC	3742	04/12/1979	270	223	28		X		
5	NE	SE	DESC	3743	08/22/1975	297	249	20		X		
5			DESC	3744	05/26/1967	266	241	23		X		
5	SW	SE	DESC	3745	06/01/1966	173	154	9		X		
5			DESC	3746	10/23/1965	264	240	10		X		
5	SE	SW	DESC	3747	05/16/1962	270	235	12		X		
5	SW	SW	DESC	3748	06/26/1976	249	231			X		
5	SW	NE	DESC	3749	01/14/1962	250	232	9		X		
5			DESC	3750	02/23/1980	240	200	5		X		
5	NE	NE	DESC	3751	06/17/1977	300	204	190	X			
5	SE	NE	DESC	3752	11/26/1977	280	218	22		X		
5	NW	NW	DESC	3753	09/18/1974	183	174	10		X		
5	SW	SW	DESC	3754	07/18/1976	239	227	20		X		
5	SE	SE	DESC	3755	03/30/1978	261	240	15		X		
5	NE	SE	DESC	3756	06/11/1973	298	238	15		X		
5	NW	SE	DESC	3757	11/14/1972	311	231	25		X		
5	SE	SE	DESC	3758	02/04/1977	160	130	10		X		
5	NW	NW	DESC	3759	06/26/1968	206	194	10		X		
5	SW	NW	DESC	3760	05/28/1965	230	218	15		X		
5	SW	SW	DESC	9202	04/21/1994	295	228	20		X		
5	SW	SW	DESC	9736	01/25/1995	294	236	16		X		
5	SW	SW	DESC	50233	04/22/1996		236	25		X		
5	SW	NE	DESC	50286	05/30/1996	314	210	40		X		
5	SE	SE	DESC	50341	06/11/1996	312	245	20		X		
5	SE	SE	DESC	50898	05/29/1997	320	239	35		X		
5	NE	SE	DESC	50992	07/10/1997	315	238	20		X		
5	SE	NE	DESC	51513	06/07/1997		237	15		X		
5	SE	SE	DESC	51834	08/12/1998	184	100	25		X		

TABLE E-1. REGISTERED WATER WELLS IN TOWNSHIP 15 SOUTH AND RANGE 13 EAST, WITHIN 4-MILE RADIUS OF THE COUTES.

Section	Quarter 160	Quarter 40	County Code	Well ID	Completion Date	Total Depth (ft)	Static Water Level (ft)	Well Yield (gal per min)	Community	Domestic/ Private	Industrial	Irrigation
5	NE	SE	DESC	53231	08/08/2000	445	346	30		X		
5	NW	NW	DESC	53844	05/08/2001	253	202	25		X		
5	SE	SW	DESC	53945								
8	NE	NE	DESC	401	09/27/1974	170	99	15		X		
8	SW	SW	DESC	402	07/09/1972	295	246	20		X		
8	SW	SW	DESC	1276	03/14/1992	298	278	37		X		
8	SE	SW	DESC	1315	05/05/1992	380	265	40		X		
8	SE	SW	DESC	1593	12/21/1992	290	270	10		X		
8	SE	SW	DESC	1593	12/21/1992	290	270	10		X		
8	SE	SW	DESC	1609	03/11/1990	290	270	30		X		
8	SE	SW	DESC	1609	03/11/1990	290	270	30		X		
8	SE	NE	DESC	3160	10/26/1963	152	105	8		X		
8	NW	NE	DESC	3818	08/10/1988	302	260	18		X		
8	SE	NW	DESC	3819	08/03/1987	192	152	15		X		
8	SW	SE	DESC	3820	10/06/1986	345	275	12		X		
8	NE	NE	DESC	3821	04/12/1982	138	104	20		X		
8	NE	NE	DESC	3822	04/11/1981	160	105	30		X		
8	NE	SW	DESC	3823	03/10/1980	310	250	15		X		
8	NE	NW	DESC	3824	01/23/1980	293	241	15		X		
8	NW	SE	DESC	3825	11/24/1979	120	70	14		X		
8	SE	NE	DESC	3826	05/03/1979	270	235	10		X		
8		NW	DESC	3827	11/03/1966	274	260	10		X		
8			DESC	3828	11/01/1961	114	103	7.5		X		
8	NE	NE	DESC	3829	08/01/1973	174	122	12		X		
8	SW	NE	DESC	3830	09/20/1973	275	260	7		X		
8	SE	NE	DESC	3831	04/11/1977	147	117	10		X		
8	SE	NE	DESC	3832	01/13/1977	142	117	15		X		
8	NW	NW	DESC	3833	02/19/1977	272	251	20		X		
8	NE	NW	DESC	3834	10/03/1978	240	240	10		X		
8	SE	NE	DESC	3835	09/14/1977	245	230	9		X		
8	SE	NW	DESC	3836	10/12/1973	285	250	25		X		
8	NE	SW	DESC	3837	09/09/1978	308	272	8		X		
8	NE	SW	DESC	3838	01/18/1973	280	245	20		X		
8	NE	SW	DESC	3839	09/22/1976	300	250	9		X		

TABLE E-1. REGISTERED WATER WELLS IN TOWNSHIP 15 SOUTH AND RANGE 13 EAST, WITHIN 4-MILE RADIUS OF THE COUTES.

Section	Quarter 160	Quarter 40	County Code	Well ID	Completion Date	Total Depth (ft)	Static Water Level (ft)	Well Yield (gal per min)	Community	Domestic/ Private	Industrial	Irrigation
8	NE	SW	DESC	3840	07/05/1972	335	268	20		X		
8	NW	SW	DESC	3841	05/29/1977	259	237	10		X		
8	SW	SW	DESC	3842	04/11/1972	303	246	20				
8	SW	SW	DESC	3843	01/28/1972	330	278	20		X		
8	SE	SW	DESC	3844	12/06/1969	300	267	20		X		
8	SE	SW	DESC	3845	11/04/1969	288	259	20		X		
8	NW	NW	DESC	3846	08/10/1959	320	252					
8	NE	NE	DESC	3847	08/24/1961	107		30		X		
8	NW	SE	DESC	3848	04/01/1958	135	115			X		
8	NW	NW	DESC	9500	09/06/1994	275	245	12		X		
8			DESC	9501	09/19/1994	320	267	25		X		
8	SW	NE	DESC	9579	10/14/1994	130	94	50		X		
8	NE	NE	DESC	50149	03/11/1996	320	258			X		
8	SE	NW	DESC	50275	05/17/1996	410	261	25		X		
8	SE	SW	DESC	50416	07/18/1996	324	275	8		X		
8	SE	SW	DESC	51587	03/23/1998	355	276	30		X		
8	NW	SW	DESC	51874	08/26/1998	315	265	22		X		
8	NW	SW	DESC	51885	08/27/1998	325	265			X		
8	NW	NW	DESC	52554	06/13/1999	272	251	7		X		
8	SE	SW	DESC	52724	11/11/1999	315	274	25		X		
8	SW	SW	DESC	52889	03/15/2000	350	265	30		X		
8	SW	SW	DESC	52996	05/15/2000	310	255	20		X		
8	SW	SE	DESC	53426	04/23/1984	310	245	55		X		
8	NW	SW	DESC	54101	09/10/2001	336	257	25		X		
8	NW	SW	DESC	54247	10/26/2001	335	250	30		X		
9			DESC	3850	05/01/1964	290	270	27		X		
9	NW	NW	DESC	3851	09/05/1963	292	252	15		X		
9		NE	DESC	3852	07/31/1972	85	36	20		X		
9	NE	NW	DESC	3853	07/15/1969	300	168	1300	X			
9	NW	SW	DESC	3854	04/11/1974	280	240	20		X		
9	SW	SW	DESC	3855	03/22/1973	285	257	20		X		
9	NW	NW	DESC	3856	01/23/1963	260	235	12		X		
9	NW	NW	DESC	3857	08/20/1958	56	35	20		X		
9	SW	NW	DESC	3858	09/06/1961	268	251	15		X		

TABLE E-1. REGISTERED WATER WELLS IN TOWNSHIP 15 SOUTH AND RANGE 13 EAST, WITHIN 4-MILE RADIUS OF THE COUTES.

Section	Quarter 160	Quarter 40	County Code	Well ID	Completion Date	Total Depth (ft)	Static Water Level (ft)	Well Yield (gal per min)	Community	Domestic/ Private	Industrial	Irrigation
9	SW	SW	DESC	3859	11/21/1962	0				X		
9			DESC	51884								
10	NW	SW	DESC	403	10/10/1978	285	255	10		X		
10	SE	SE	DESC	3860	04/08/1987	385	294	20				
10	NW	SW	DESC	3861	03/28/1987	343	255	20		X		
10	NW	NE	DESC	3862	04/12/1984	305	265	20		X		
10	NE	NW	DESC	3863	08/13/1979	319	264	20		X		
10			DESC	3864	05/29/1973	311	283	15		X		
10			DESC	3865	01/28/1969	325	280	25		X		
10			DESC	3866	02/24/1969	360	290	25		X		
10	SW	NE	DESC	3867	08/20/1967	313	272	20		X		
10	SW	NE	DESC	3868	05/22/1978	322	300	11		X		
10	NW	NW	DESC	3869	03/02/1977	300	250	15		X		
10	NW	NW	DESC	3870	04/29/1971	319	284	18		X		
10	NW	SW	DESC	3871	01/23/1966	59	39	30		X		
10	NW	SW	DESC	3872	02/16/1966	51	39	3		X		
10	NE	SW	DESC	52013	10/09/1998	355	295	15		X		
10	SW	NE	DESC	52269	09/19/1997	300	270			X		
10	NE	NW	DESC	52620	08/28/1999	390	300	28		X		
10	SW	NW	DESC	52723	11/11/1999	790	698	20		X		
10	SW	NE	DESC	53051	05/01/2000	325	289	10		X		
11	NE	NE	DESC	1768	05/17/1993	375	325	30		X		
12	SW	NW	DESC	1218	05/10/1991	293	161	10		X		
12	SW	NE	DESC	3873	04/10/1980	267	228	12		X		
12			DESC	3874	11/12/1977	267	214	10		X		
12	NW	SE	DESC	3875	08/20/1959	270	230	10		X		
12	SW	SW	DESC	3876	05/04/1977	305	275	10		X		
13	NW	NE	DESC	3877	12/12/1980	302	241	15		X		
14	SE	SE	DESC	3878	03/06/1979	370	330	20		X		
16	NW	SW	DESC	3879	02/14/1975	452	265	1174	X			
16	SE	SE	DESC	3880	01/23/1978	358	268	277				X
17	NW	NW	DESC	1228	10/29/1991	350	278	10		X		
17	SE	NW	DESC	3881	12/12/1985	220	170	30		X		
17			DESC	3882	11/15/1970	314	284	12		X		

TABLE E-1. REGISTERED WATER WELLS IN TOWNSHIP 15 SOUTH AND RANGE 13 EAST, WITHIN 4-MILE RADIUS OF THE COUTES.

Section	Quarter 160	Quarter 40	County Code	Well ID	Completion Date	Total Depth (ft)	Static Water Level (ft)	Well Yield (gal per min)	Community	Domestic/ Private	Industrial	Irrigation
17			DESC	3883	08/30/1967	305	280	12		X		
17	NW	NW	DESC	3884	02/29/1960	350	278	15		X		
17	NE	NE	DESC	3885	07/19/1965	302	237	15		X		
17	NE	NW	DESC	3886	05/08/1965	330	290	16		X		
17	NW	NW	DESC	3887	04/08/1960	334	300	0		X		
17	SE	NE	DESC	3888	08/03/1960	335	275	15		X		
17			DESC	9407	02/14/1994	340	271	36		X		
18	NW	SE	DESC	404	03/14/1980	366	280	10		X		
18	SW	SE	DESC	405	10/20/1972	310	265	15		X		
18	NE	SW	DESC	1629	02/18/1993	380	275	21		X		
18			DESC	3889	01/02/1990	295	248	12.5		X		
18	SW	SE	DESC	3890	09/03/1987	335	267	30		X		
18	NE	SW	DESC	3891	07/30/1983	320	249	20		X		
18	NW	NW	DESC	3892	05/26/1980	323	255	6				
18	SE	SW	DESC	3893	03/18/1980	350		11				
18	SW	SE	DESC	3894	11/14/1979	357	325	8		X		
18	SW	SW	DESC	3895	03/09/1979	320	270	10		X		
18			DESC	3896	10/02/1970	285	255	15		X		
18			DESC	3897	09/26/1970	355	250	20		X		
18			DESC	3898	06/16/1967	320	284	16		X		
18			DESC	3899	11/29/1966	310	295	12		X		
18	NW	SE	DESC	3900	11/22/1961	300	268	12		X		
18	NW	NE	DESC	3901	05/11/1974	295	240	19		X		
18	SE	NE	DESC	3902	02/24/1971	302	266	20		X		
18	SE	NE	DESC	3903	10/05/1968	440	277	250			X	
18	NW	NW	DESC	3904	06/28/1978	321	261	30		X		
18	NW	NW	DESC	3905	05/11/1972	342	292	15		X		
18	SW	NW	DESC	3906	04/07/1977	310	255	6				
18	NE	SW	DESC	3907	05/16/1974	314	270	20		X		
18	SW	SW	DESC	3908	04/08/1977	297	273	10				
18	NW	NE	DESC	3909	07/15/1975	302	252	14		X		
18	SE	NE	DESC	3910	12/31/1952	400	320	150			X	
18	NW	NW	DESC	3911	06/13/1979	300	255	10		X		
18	SW	NW	DESC	3913	09/17/1970	309	261	10		X		

TABLE E-1. REGISTERED WATER WELLS IN TOWNSHIP 15 SOUTH AND RANGE 13 EAST, WITHIN 4-MILE RADIUS OF THE COUTES.

Section	Quarter 160	Quarter 40	County Code	Well ID	Completion Date	Total Depth (ft)	Static Water Level (ft)	Well Yield (gal per min)	Community	Domestic/ Private	Industrial	Irrigation
18	SW	NW	DESC	3914	03/17/1971	315	270	10				
18	NE	SW	DESC	3915	02/10/1970	280	275	5		X		
18	SW	SE	DESC	3916	07/06/1970	312	272	20		X		
18	SE	NW	DESC	3917	12/05/1966	285	270	16		X		
18	SE	NW	DESC	3918	07/20/1955	305	60	12		X		
18	SW	NE	DESC	3919	10/17/1962	175	142	12		X		
18	NE	SE	DESC	3920	04/25/1967	300	233	20		X		
18	NE	SE	DESC	3921	08/16/1963	302	270	12		X		
18			DESC	3922	08/06/1970	275	250	15		X		
18			DESC	3923	08/18/1970	340	302	15		X		
18	NE	SW	DESC	3924	03/18/1968	285	275	10		X		
18	NE	SW	DESC	3925	04/15/1964	306	270	10		X		
18	SW	SW	DESC	3926	08/04/1965	336	286	15		X		
18	SE	SW	DESC	3927	06/05/1966	320	295	10		X		
18	SE	SW	DESC	3928	07/13/1965	339	299	15		X		
18	NE	SW	DESC	9077	01/21/1994	340	274	25		X		
18	NE	SE	DESC	9456	08/12/1994	390	270	50		X		
18	NW	NE	DESC	9516	09/15/1994	295	212	20		X		
18	SE	SW	DESC	9923	05/29/1995	390	294	20		X		
18	NE	NE	DESC	50229	05/20/1994	308	250	15		X		
18	NE	NE	DESC	50268	05/14/1996	379	296	25		X		
18			DESC	52210	01/15/1996	360	319	12		X		
18	SW	SE	DESC	53786	04/02/2001	385	288	10		X		
18	NE	SE	DESC	53910	05/25/2001	370	277	20		X		
19	NE	SW	DESC	406	08/24/1973	448	375	20		X		
19	NW	SW	DESC	934	05/30/1991	412	320	20		X		
19	SE	NW	DESC	1001	08/16/1991	380	287	20		X		
19	NE	SW	DESC	1087	10/23/1991	380	295	10		X		
19	SE	SE	DESC	1117	11/14/1991	400	331	12		X		
19	NE	SW	DESC	3929	10/25/1982	362	325	16		X		
19	NW	NE	DESC	3930	05/01/1981	404	262	200				X
19	SW	SE	DESC	3931	08/01/1979	595	500	10				
19	NE	NE	DESC	3932	04/14/1978	355	303	8		X		
19	SW	NE	DESC	3933	03/31/1973	338	307	12		X		

TABLE E-1. REGISTERED WATER WELLS IN TOWNSHIP 15 SOUTH AND RANGE 13 EAST, WITHIN 4-MILE RADIUS OF THE COUTES.

Section	Quarter 160	Quarter 40	County Code	Well ID	Completion Date	Total Depth (ft)	Static Water Level (ft)	Well Yield (gal per min)	Community	Domestic/ Private	Industrial	Irrigation
19	NW	NW	DESC	3934	03/22/1978	355	309	12		X		
19	NW	NE	DESC	3935	02/07/1964	350	300	20		X		
19	NE	NE	DESC	3936	10/31/1988	345	290	18		X		
19	NE	SW	DESC	3937	12/21/1978	357	313	7		X		
19	SE	NE	DESC	3944	06/16/1977	375	370			X		
19	SE	NE	DESC	3969	04/27/1977	380	360			X		
19	SE	NW	DESC	8469	07/09/1993	390	297	20		X		
19	SW	NE	DESC	50186	03/26/1996	386	313	20		X		
19	NW	SW	DESC	50320	06/05/1996	415	336	35		X		
19	SW	NW	DESC	50459	08/09/1996	377	290	25		X		
19	NE	NE	DESC	50778	03/11/1997	380	310	40		X		
19	NW	SW	DESC	51468	12/15/1997	422	337	25		X		
20	NW	NE	DESC	3938	05/12/1981	362	287	10		X		
20			DESC	3939	11/10/1972	318	275	15		X		
20			DESC	3940	05/13/1968	320	295	20		X		
20	NW	NW	DESC	3941	08/17/1972	322	285	8				
20	NE	NE	DESC	3942	12/15/1965	308	220	15		X		
20	NW	NE	DESC	3943	04/11/1959	340	290	10		X		
20	NW	SE	DESC	3952	12/13/1983	740	314	225				X
20	NE	NE	DESC	51647	03/23/1998	802	259	2300	X			
20	NE	NW	DESC	53039	05/26/2000	340	297	9		X		
21			DESC	3945	02/12/1988	240	189	7		X		
21	NW	SW	DESC	3946	02/12/1986	405	340	10		X		
21	NW	SW	DESC	3948	12/09/1975	210	155	14.5		X		
21	SE	NE	DESC	3949	09/27/1973	390	306	20			X	
21	SW	SW	DESC	3950	09/05/1971	192	137	20		X		
21	SW	SW	DESC	52999	05/16/2000	265	179	25		X		
22	SE	NW	DESC	407	05/24/1985	765	362	1300	X			
22		SW	DESC	3951	01/30/1987	801	310		X			
22			DESC	3953	09/21/1979	452	315	1100	X			
23		NE	DESC	3954	02/20/1979	420	375	30				
25	NW	SW	DESC	3944	06/16/1977	375	370			X		
25			DESC	3955	01/16/1980	230	216	6		X		
28	NW	NW	DESC	3956	09/05/1975	365	312	6			X	

TABLE E-1. REGISTERED WATER WELLS IN TOWNSHIP 15 SOUTH AND RANGE 13 EAST, WITHIN 4-MILE RADIUS OF THE COUTES.

Section	Quarter 160	Quarter 40	County Code	Well ID	Completion Date	Total Depth (ft)	Static Water Level (ft)	Well Yield (gal per min)	Community	Domestic/ Private	Industrial	Irrigation
28	SW	SW	DESC	51967	05/22/1998	450	358	425				X
29	NW	SE	DESC	981	07/29/1991	385	320	24		X		
29	NW	SW	DESC	1252	03/27/1992	430	355	30		X		
29	SE	SW	DESC	1714	04/26/1993	465	381	20		X		
29	SE	SW	DESC	3957	01/16/1986	413	355	5		X		
29	SW	NW	DESC	3958	08/03/1983	397	351	8		X		
29	NE	SW	DESC	3959	09/08/1980	420	380	25		X		
29	NW	NW	DESC	3960	04/08/1978	420	384	15		X		
29			DESC	3961	11/02/1966	376	355	24			X	
29	NE	NW	DESC	3962	04/17/1975	373	323	15		X		
29	NE	NW	DESC	3963	04/11/1973	378	336	18		X		
29	NW	SE	DESC	3964	10/17/1960	352	297			X		
29	NW	SE	DESC	3965	02/19/1976	361	330	13		X		
29	SW	NW	DESC	3978	03/31/1978	440	372	10				
29	SW	SW	DESC	3979	02/18/1970	372	332	20		X		
29	SE	SW	DESC	3980	05/01/1969	430	360	25		X		
29	NE	SE	DESC	3981	07/19/1974	472	332	12	X	X		
29	NE	SE	DESC	3982	06/14/1974	466	256	5	X	X		
29	SW	NW	DESC	3983	09/04/1965	363	338	13		X		
29			DESC	51281								
29	SE	SW	DESC	54110	08/27/2001	450	368	25		X		
30	NE	SE	DESC	64	05/29/1990	443	381	18		X		
30	NW	NE	DESC	81	06/21/1990	522	479	12		X		
30	NW	SW	DESC	408	02/28/1979	373	316	18		X		
30	NE	SE	DESC	409	06/22/1989	385	358	12		X		
30	NE	SE	DESC	1592	12/10/1992	460	372	27		X		
30	NW	NW	DESC	3966	02/11/1981	400	354	20		X		
30	SE	SE	DESC	3967	05/30/1979	373	340	5		X		
30	NE	NW	DESC	3968	05/04/1983	395	362	15		X		
30			DESC	3969	04/27/1977	380	360			X		
30			DESC	3970	05/18/1972	385	355	75	X			
30	NW	NW	DESC	3971	10/06/1977	360	328	15		X		
30	NE	SW	DESC	3972	03/01/1979	388	350	10		X		
30	NE	SE	DESC	3973	06/02/1977	385	346	25		X		

TABLE E-1. REGISTERED WATER WELLS IN TOWNSHIP 15 SOUTH AND RANGE 13 EAST, WITHIN 4-MILE RADIUS OF THE COUTES.

Section	Quarter 160	Quarter 40	County Code	Well ID	Completion Date	Total Depth (ft)	Static Water Level (ft)	Well Yield (gal per min)	Community	Domestic/ Private	Industrial	Irrigation
30	NE	SE	DESC	3974	07/30/1977	352	333	10		X		
30	NE	SE	DESC	3975	02/28/1975	382	360	9		X		
30	SW	SE	DESC	3976	05/30/1978	414	324	20		X		
30	SW	SE	DESC	3977	05/03/1972	382	317	20		X		
30	NE	SE	DESC	3984	08/24/1989	285	235	12		X		
30			DESC	3985	08/11/1984	364	340	8		X		
30	NW	SE	DESC	3986	07/27/1982	402	337	7		X		
30	NW	SW	DESC	3987	08/17/1981	345	320	15		X		
30	SE	NW	DESC	8620	11/07/1993	530	420	15		X		
30	NW	SW	DESC	52180	02/05/1999	415	345	22		X		
30	NE	SW	DESC	52374	05/12/1999	393	337	25		X		
30	NE	NW	DESC	53172	07/06/2000	472	339	60		X		
32			DESC	4003	07/17/1968	430	395	20		X		
32	NW	NW	DESC	4004	05/28/1965	400	373	12		X		
32	NE	NW	DESC	4005	06/24/1967	410	391	20		X		
36			DESC	4006	06/02/1969	400	381	15		X		
36	NW	NE	DESC	52977	04/26/2000	460	380	30		X		
36	NW	NE	DESC	53079	06/08/2000	500	380	30		X		

NOTE: County Code “DESC” is Deschutes County.

TABLE E-2. REGISTERED WATER WELLS IN TOWNSHIP 15 SOUTH AND RANGE 14 EAST, WITHIN 4-MILE RADIUS OF THE COUTES.

Section	Quarter 160	Quarter 40	County Code	Well ID	Completion Date	Total depth (ft)	Static water Level (ft)	Well Yield (gal per min)	Community	Domestic/ Private
7			CROO	1737	12/07/1967	105	76	10		X
19		NE	CROO	1795	12/19/1978	420	390	10		X
21	SE	NE	CROO	1796	06/05/1981	357	302	25		X
21	SE	NE	CROO	1797	11/07/1978	360	315	15		X
21	SE	NE	CROO	1798	11/28/1978	390	310	15		X
21	NE	SE	CROO	1799	11/02/1964	348	326	15		X
28	NE	NE	CROO	1848	06/22/1988	403	340	10		X
28	NE	NE	CROO	1849	11/23/1987	405		25		X
28	SW	SE	CROO	1850	06/24/1981	425	360	20		X
28	SW	SE	CROO	2967	12/10/1993	450	390	15		X
28	SW	SE	CROO	2968	12/13/1993	388				X
28	NE	NE	CROO	3025	06/07/1994	405	340	10		X
28	NW	NW	CROO	51574	01/11/2001	460	361	30		X
28	NW	NW	CROO	51576	01/05/2001	440	345	25		X
28	SE	SW	CROO	51667	07/20/2001	450	362	25		X
28			CROO	51684	08/15/2001	475	360	50		X
28	SE	SE	CROO	51773	12/07/2001	485	399	25		X
29			CROO	1851	05/12/1988	875	284	1.5		
29	SE	NE	CROO	50267	05/28/1997	495	385	300		X
29	NW	NW	CROO	50462	01/22/1998	499	379	300		X
29	NE	NW	CROO	51665	07/19/2001	480	400	25		X
31	SE	SW	CROO	1852	01/02/1985	492	370	97		
31			CROO	1854	01/23/1989	700	410	100	X	
31			CROO	1855	12/30/1978	640	410	10		X

TABLE E-3. REGISTERED WATER WELLS IN TOWNSHIP 16 SOUTH AND RANGE 13 EAST, WITHIN 4-MILE RADIUS OF THE COUTES.

Section	Quarter 160	Quarter 40	County Code	Well ID	Completion Date	Total Depth (ft)	Static Water Level (ft)	Well Yield (gal per min)	Domestic/ Private
3			DESC	4647	10/06/1968	63	26	20	X
11	NW	NW	DESC	4654	08/14/1973	295	245	21	X
12	SW	NE	DESC	816	08/17/1990	410	380	15	X

TABLE E-4. REGISTERED WATER WELLS IN TOWNSHIP 14 SOUTH AND RANGE 13 EAST, WITHIN 4-MILE RADIUS OF THE COUTES.

Section	Quarter 160	Quarter 40	County Code	Well ID	Completion Date	Total Depth (ft)	Static Water Level (ft)	Well Yield (gal per min)	Domestic	Irrigation
33	NE	NE	DESC	223	11/09/1990	300	255	15	X	
33	NE	SE	DESC	320	01/25/1973	506	437	10	X	
33	SW	NW	DESC	1049	09/01/1991	175	150	20	X	
33	SW	NW	DESC	1723	05/08/1993	218		20	X	
33	SE	NE	DESC	2647	07/27/1984	275	237	20	X	
33	SW	SW	DESC	2648	05/30/1981	358	300	50	X	
33	SE	SE	DESC	2649	11/23/1979	255	225	20	X	
33			DESC	2650	04/16/1973	254	237	6	X	
33			DESC	2651	11/28/1970	275	238	18	X	
33			DESC	2652	01/04/1972	262	240	24	X	
33			DESC	2653	04/26/1969	229	217	10	X	
33			DESC	2654	03/28/1969	285	250	25	X	
33			DESC	2655	09/01/1966	230	209	10	X	
33			DESC	2656	10/04/1966	261	240	15	X	
33	SE	NE	DESC	2657	03/23/1973	280	255	15	X	
33			DESC	2658	09/15/1966	265	245	10	X	
33			DESC	2659	09/22/1966	264	246	10	X	
33			DESC	2660	09/06/1966	256	240	16	X	
33	NE	SE	DESC	2661	08/16/1963	275	244	21	X	
33	SW	NW	DESC	2662	03/05/1978	211		10	X	
33	SW	SW	DESC	2663	06/05/1978	150	115	20	X	
33	SW	SW	DESC	2664	08/10/1973	178	139	20	X	
33	SE	SE	DESC	2665	08/11/1972	270	220	20	X	
33	NW	SE	DESC	2666	08/17/1970	306	267	20	X	
33	NE	SE	DESC	2667	06/09/1964	255	238	14	X	
33	SW	SE	DESC	2668	10/15/1964	250	237	16	X	
33	SE	SE	DESC	50403	07/17/1996	321	252	38	X	
33	NE	SE	DESC	50582	11/08/1995	300	240	30	X	
33	NE	SE	DESC	50634	11/11/1996		247	30	X	
33	NE	SE	DESC	50841	04/16/1997		245	30	X	
33	SE	SE	DESC	53291	09/15/2000	342	253	45	X	
34	SW	SE	DESC	71	06/08/1990	315	221	22	X	
34	SW	SE	DESC	144	08/27/1990	312	243	20	X	

TABLE E-4. REGISTERED WATER WELLS IN TOWNSHIP 14 SOUTH AND RANGE 13 EAST, WITHIN 4-MILE RADIUS OF THE COUTES.

Section	Quarter 160	Quarter 40	County Code	Well ID	Completion Date	Total Depth (ft)	Static Water Level (ft)	Well Yield (gal per min)	Domestic	Irrigation
34	NE	SW	DESC	321	03/29/1978	297	235	20	X	
34	SE	NW	DESC	518	11/21/1990	260	222	12	X	
34	NE	SE	DESC	2669	10/26/1989	294	232	12	X	
34	SE	NW	DESC	2670	03/18/1986	265	230	10	X	
34	SE	NW	DESC	2671	09/17/1984	78	22	20	X	
34	SE	NW	DESC	2672	10/28/1983	160	125	14	X	
34	SW	NE	DESC	2673	04/17/1980	311	255	10	X	
34			DESC	2674	09/07/1978	300	230	10	X	
34	NW	SE	DESC	2675	08/17/1975	280	249	10	X	
34			DESC	2676	12/20/1973	152	105	18	X	
34			DESC	2677	11/04/1970	274	240	20	X	
34			DESC	2678	10/28/1968	247	216	20	X	
34			DESC	2679	12/15/1962	200	170	10	X	
34	SW	NE	DESC	2680	04/01/1978	297	245	15	X	
34	NE	NW	DESC	2681	10/17/1969	241	211	20	X	
34	SW	NW	DESC	2682	03/01/1979	252	225	10	X	
34	NW	SW	DESC	2683	09/14/1978	290	251	12	X	
34	SW	SW	DESC	2684	06/11/1973	275	245	10	X	
34	NW	SW	DESC	2685	11/08/1975	290		25	X	
34	NE	SE	DESC	2686	08/11/1977	255	235	7		
34	SE	NW	DESC	2687	01/19/1968	225	198	12	X	
34	SE	NE	DESC	2688	07/26/1965	247	225	20	X	
34	NE	SW	DESC	2689	09/18/1957	45		10	X	
34	SE	NW	DESC	2690	02/20/1964	267	224	6	X	
34	SW	SW	DESC	2691	03/08/1966	266	241	10	X	
34	SW	SW	DESC	2692	11/14/1965	265	241	8	X	
34	SE	NE	DESC	9979	06/15/1995	315	228	25	X	
34	SW	NE	DESC	50231	04/26/1996	300	220	25	X	
34	SW	SW	DESC	50779	02/03/1997	300	255	10	X	
34	SE	SE	DESC	51093	08/29/1997	330	260	14	X	
34	NE	SE	DESC	52268	03/24/1999	330	260	22	X	
34	SE	NW	DESC	52553	06/15/1999	300	252	10	X	
34	SE	SW	DESC	52692	09/29/1999	290	245	19	X	
34	NW	SE	DESC	52770	12/13/1999	320	255	30	X	

TABLE E-4. REGISTERED WATER WELLS IN TOWNSHIP 14 SOUTH AND RANGE 13 EAST, WITHIN 4-MILE RADIUS OF THE COUTES.

Section	Quarter 160	Quarter 40	County Code	Well ID	Completion Date	Total Depth (ft)	Static Water Level (ft)	Well Yield (gal per min)	Domestic	Irrigation
34	NW	SW	DESC	53189	07/06/2000	335	236	10	X	
34	NW	NW	DESC	54201	10/20/2001	280	205	50	X	
35	NW	SW	DESC	6	04/03/1990	293	230	15	X	
35	SW	SW	DESC	322	06/02/1982	260	220	15	X	
35	NW	NE	DESC	323		0	0	15	X	
35	NE	NW	DESC	324	03/27/1972	130	90	32	X	
35	NW	SE	DESC	325	12/21/1978	285	256	15	X	
35	NW	NW	DESC	1046	09/19/1991	260	222	15	X	
35			DESC	1449	08/04/1992	336	236		X	
35	SW	SW	DESC	1483	10/15/1992	300	222	12	X	
35	SW	NW	DESC	1625	02/10/1993	280	234	18	X	
35	SW	SE	DESC	1634	02/24/1993	335	280	12	X	
35		NE	DESC	2520	01/21/1978	287	142	15	X	
35	NE	SE	DESC	2673	04/17/1980	311	255	10	X	
35	SW	SW	DESC	2693	09/14/1989	308	260	15	X	
35	NE	NE	DESC	2694	06/16/1988	318	228	20	X	
35	NE	NE	DESC	2695	06/14/1988				X	
35	SW	SW	DESC	2696	03/27/1988	310	255	12	X	
35	SW	NW	DESC	2697	10/27/1987	285	206	28	X	
35	SE	SW	DESC	2698	02/06/1981	295	265	15	X	
35	SE	SW	DESC	2699	02/20/1981	290	255	12	X	
35		NE	DESC	2700	09/21/1980	295	240	12	X	
35	SW	SE	DESC	2701	05/19/1980	313	35	10	X	
35	NE	SW	DESC	2703	01/31/1980	293	224	18	X	
35	NW	SW	DESC	2704	10/18/1979	255	220	10	X	
35	SW	SW	DESC	2705	10/08/1979	278	231	10	X	
35	NW	NE	DESC	2706	10/11/1977	235	185	10	X	
35			DESC	2707	05/28/1979	295	245	10	X	
35	SW	SW	DESC	2708	04/20/1979	342	314	9	X	
35	NE	SW	DESC	2709	08/30/1978	285	216	20	X	
35	SE	SW	DESC	2710	06/20/1975	290	267	16.6	X	
35		NE	DESC	2711	11/26/1963	285	263	10	X	
35		NE	DESC	2712	09/25/1978	290		6	X	
35	SW	NE	DESC	2715	04/09/1979	342	296	9	X	

TABLE E-4. REGISTERED WATER WELLS IN TOWNSHIP 14 SOUTH AND RANGE 13 EAST, WITHIN 4-MILE RADIUS OF THE COUTES.

Section	Quarter 160	Quarter 40	County Code	Well ID	Completion Date	Total Depth (ft)	Static Water Level (ft)	Well Yield (gal per min)	Domestic	Irrigation
35	NE	NW	DESC	2716	06/21/1978	255	225	12	X	
35	SW	SW	DESC	2717	08/26/1978	285	250	12	X	
35	SW	SE	DESC	2718	08/04/1978	290	260	20		
35	NW	NE	DESC	2719	12/16/1975	270	225	8	X	
35	NW	NE	DESC	2720	07/29/1977	220	145	10	X	
35	SW	NE	DESC	2721	11/27/1972	282	242	9	X	
35	SE	NE	DESC	2722	07/20/1977	307	227	15	X	
35	SE	NE	DESC	2723	06/04/1973	280	250	15	X	
35	NE	NW	DESC	2724	04/13/1978	260	204	20	X	
35	NW	NW	DESC	2725	03/23/1972	121	95	15	X	
35	NE	SW	DESC	2726	10/19/1977	267	217	15	X	
35	SW	SW	DESC	2727	11/20/1975	301	256	18.5	X	
35	SW	SW	DESC	2728	09/18/1979	302	230	10	X	
35	SE	SW	DESC	2729	06/02/1978	283	250	15	X	
35	SE	SW	DESC	2730	12/22/1976	285	255	33	X	
35	NE	SE	DESC	2731	03/16/1978	260	240	10	X	
35	NW	SE	DESC	2732	10/23/1978	290	243	24	X	
35	SE	SE	DESC	2733	06/23/1978	322	258	18	X	
35	SE	SE	DESC	2734	01/18/1977	292	265	13	X	
35			DESC	2748	09/20/1973	327	258	12	X	
35	SE	NW	DESC	8958	11/18/1993	340	280	21	X	
35	SW	SE	DESC	9045	12/03/1993	312	279	34	X	
35	SW	SE	DESC	9172	03/28/1994	303	273	12	X	
35	SE	NW	DESC	9414	08/01/1994	300	234	25	X	
35	SW	SE	DESC	9617	11/15/1994	325	275	25	X	
35		SW	DESC	9877	04/17/1995	300	230	16	X	
35	SE	SW	DESC	9913	05/26/1995	309	249	20	X	
35	NE	SE	DESC	10107	06/26/1995	300	258	22	X	
35	SW	NE	DESC	10227	10/23/1995	330	255	20	X	
35	NW	NE	DESC	50406	06/21/1996	324	233	18	X	
35	NE	NE	DESC	50657	12/04/1996	285	239	7	X	
35	SE	SE	DESC	51113	09/10/1997	340	278	25	X	
35	SE	NW	DESC	51573	03/13/1998	291	240	25	X	
35	SE	NE	DESC	51698	05/21/1998	310	253	35	X	

TABLE E-4. REGISTERED WATER WELLS IN TOWNSHIP 14 SOUTH AND RANGE 13 EAST, WITHIN 4-MILE RADIUS OF THE COUTES.

Section	Quarter 160	Quarter 40	County Code	Well ID	Completion Date	Total Depth (ft)	Static Water Level (ft)	Well Yield (gal per min)	Domestic	Irrigation
35	SE	SW	DESC	53278	11/21/1977	285	255	33	X	
35	NE	SE	DESC	53639	01/05/2001	290	250	30	X	
35	NE	SE	DESC	53684	02/21/2001	311	259	25	X	
35	NE	SW	DESC	54000	06/11/2001	315	251	30	X	
35	NE	SW	DESC	54063	08/08/2001	330	252	30	X	
36		NE	DESC	118	06/20/1990	283	220	45		
36			DESC	118	06/20/1990	283	220	45		
36			DESC	326	06/24/1981	280	250	30	X	
36			DESC	327	04/11/1977	305	266	15	X	
36	NW	SW	DESC	328	04/11/1976	280	245	8	X	
36	NW	SW	DESC	328	04/11/1976	280	245	8	X	
36			DESC	750	01/06/1991	332	245	50	X	
36	SW	NW	DESC	1321	05/18/1992	310	250	15	X	
36	NE	NE	DESC	1448	08/18/1992	300	240	23	X	
36	SW	SE	DESC	1469	01/23/1993	300	232	16	X	
36	SW	NW	DESC	1504	10/02/1992	300	260	30	X	
36	SE	NW	DESC	1606	12/28/1992	300	248	20	X	
36	SE	SW	DESC	1752	05/26/1993	300	253	26	X	
36	NW	SW	DESC	2527	01/21/1978	280	245	10	X	
36	SW	NE	DESC	2712	09/25/1978	290		6	X	
36	NW	NE	DESC	2713	08/27/1982	217	116	60	X	
36	NW	NE	DESC	2714	09/09/1978	305	283	12		
36	SW	SW	DESC	2723	06/04/1973	280	250	15	X	
36	SE	SE	DESC	2735	12/12/1987	310	270		X	
36	SE	SE	DESC	2736	05/03/1985	280	240	10	X	
36	NE	NE	DESC	2737	10/07/1983	347	219	25	X	
36			DESC	2738	01/25/1982	295	247	10	X	
36	SE	NE	DESC	2739	05/10/1980	290	270	10	X	
36	SW	SE	DESC	2740	08/09/1984	285	255	12	X	
36			DESC	2741	03/05/1984	310	230	10	X	
36	SE	SE	DESC	2742	06/03/1979	279	243	10	X	
36		SW	DESC	2743	06/29/1983	312	270	19	X	
36			DESC	2744	01/19/1983	280	229	6	X	
36	NW	NE	DESC	2745	01/20/1983	275	215	25	X	

TABLE E-4. REGISTERED WATER WELLS IN TOWNSHIP 14 SOUTH AND RANGE 13 EAST, WITHIN 4-MILE RADIUS OF THE COUTES.

Section	Quarter 160	Quarter 40	County Code	Well ID	Completion Date	Total Depth (ft)	Static Water Level (ft)	Well Yield (gal per min)	Domestic	Irrigation
36		NE	DESC	2746	03/26/1982	245	225	12	X	
36	NW	NE	DESC	2747	10/15/1982	285	231	25	X	
36	SW	NE	DESC	2749	08/29/1982	285	205	30	X	
36		SE	DESC	2750	09/26/1980	303	243	12	X	
36	NE	NE	DESC	2751	11/15/1979	275	235	12	X	
36			DESC	2752	04/20/1979	280	240	30	X	
36			DESC	2753	09/29/1979	300	256	12	X	
36			DESC	2754	07/31/1979	291	235	12	X	
36			DESC	2755	07/24/1979	300	210	15	X	
36			DESC	2756	11/09/1988	310	268	15	X	
36			DESC	2757	09/26/1978	240	210	10	X	
36			DESC	2758	01/23/1979	285	225	10	X	
36			DESC	2759	05/06/1978	297	237	22	X	
36	NW	SW	DESC	2760	08/30/1979	280	238	20	X	
36	NW	SW	DESC	2761	07/23/1975	280	239	16.5	X	X
36	NE	SE	DESC	2762	07/18/1975	270	235	24	X	
36		NW	DESC	2763	11/18/1967	168	120	10	X	
36	NE	NE	DESC	2764	07/28/1978	298	255	23	X	
36	NW	NE	DESC	2765	12/29/1978	305	260	20	X	
36		SE	DESC	2766	08/21/1978	297	245	10	X	
36	NE	NE	DESC	2767	03/29/1974	311	215	20	X	X
36	SE	SW	DESC	2768	08/19/1978	295	245	10	X	
36		SW	DESC	2769	05/02/1983	275	270	10	X	
36	NW	NW	DESC	2770	02/09/1977	290	239	10	X	
36	NW	NW	DESC	2771	04/16/1976	272	229	20	X	
36	SE	NW	DESC	2773	09/27/1975	294	240	29	X	
36	SW	SW	DESC	2774	05/02/1980	342	262	12	X	
36	NW	SW	DESC	2775	12/27/1977	275	217	20	X	
36	SW	NE	DESC	2776	04/29/1968	290	230	20	X	
36	SE	NE	DESC	9189	04/05/1994	300	247	12	X	
36	NW	SE	DESC	9286	06/16/1994	305	259	14	X	
36	NE	SE	DESC	9287	06/17/1994	305	236	12	X	
36	SE	NE	DESC	9504	09/17/1994	300	247	25	X	
36			DESC	9747	02/09/1995	315	255	30	X	

TABLE E-4. REGISTERED WATER WELLS IN TOWNSHIP 14 SOUTH AND RANGE 13 EAST, WITHIN 4-MILE RADIUS OF THE COUTES.

Section	Quarter 160	Quarter 40	County Code	Well ID	Completion Date	Total Depth (ft)	Static Water Level (ft)	Well Yield (gal per min)	Domestic	Irrigation
36	SE	SW	DESC	9814	03/28/1995	290	245	16	X	
36	SW	SE	DESC	9842	04/17/1995	290	248	40	X	
36	NW	NE	DESC	50030	11/27/1995	300	226	30	X	
36	SE	NW	DESC	50171	03/15/1996	300	250	25	X	
36	SE	SE	DESC	50249	04/25/1996	295	245	25	X	
36	SW	NE	DESC	50387	07/08/1996	343	280	25	X	
36	SW	SW	DESC	50430	07/29/1996	305	259	20	X	
36	SE	NW	DESC	50521	09/11/1996	310	260	20	X	
36	SE	SE	DESC	50580	11/17/1995	310	240	25	X	
36	SW	NW	DESC	50623	10/30/1996	320	262	25	X	
36	SW	SE	DESC	50705	01/08/1997	312	247	20	X	
36	SW	NW	DESC	50742	02/28/1997	307	263	30	X	
36	NW	NW	DESC	50815	04/11/1997	300	233	100	X	
36	NW	NW	DESC	51044	08/06/1997	310	249	35	X	
36	NW	SW	DESC	51055	08/20/1997	305	239	25	X	
36	NE	NW	DESC	51382	10/27/1997	308	249	25	X	
36	NE	SE	DESC	51665	05/11/1998	310	238	26	X	
36	NW	SE	DESC	51727	06/09/1998	319	242	12	X	
36	SW	NW	DESC	51754	06/23/1998	325	250	25	X	
36	NE	SE	DESC	52038	11/11/1998	335	238	25	X	
36	SE	NW	DESC	52096	12/07/1998	298	251	25	X	
36	NW	SE	DESC	52197	02/22/1999	298	242	25	X	
36	NW	NE	DESC	52204	02/23/1999	305	247	35	X	
36	NW	NE	DESC	52942	04/18/2000	320	263	20	X	
36	NW	NE	DESC	54027	07/20/2001	312	250	20	X	

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data, and Information Service

Global Summary of the Month for 2017

Generated on 11/13/2018

National Centers for Environmental Information
151 Patton Avenue
Asheville, North Carolina 28801

Current Location: Elev: 3043 ft. Lat: 44.2558° N Lon: -121.1392° W
Station: **REDMOND AIRPORT, OR US USW00024230**

Date	**Temperature (F)**													**Precipitation (Inches)**								
Elem ->	TAVG	TMAX	TMIN	HTDD	CLDD	EMXT		EMNT		DX90	DX32	DT32	DT00	PRCP	EMXP		SNOW	EMSD		DP01	DP10	DP1X
Month	Mean	Mean Max.	Mean Min	Heating Degree Days	Cooling Degree Days	Highest	High Date	Lowest	Low Date	Number of Days				Total	Greatest Observed		Snow, Sleet			Number of Days		
										Max >= 90	Max <= 32	Min <= 32	Min <= 0		Amount	Date	Total Fall	Max Depth	Max Date	>=.01	>=.10	>=1.0
Jan	22.2	31.3	13.2	1326	0	45	27	-14	05	0	13	30	6	1.63	0.41	07				15	4	0
Feb	35.0	44.1	26.0	839	0	57	14	16	24	0	2	21	0	1.15	0.41	07				14	4	0
Mar	42.9	55.4	30.5	684	0	69	14	19	05	0	0	20	0	0.58	0.27	29				7	3	0
Apr	43.4	56.9	29.9	648	0	68	05	18	15	0	0	20	0	0.89	0.18	18				14	3	0
May	53.7	72.0	35.4	360	9	91	29	22	07	2	0	13	0	0.17	0.06	05				7	0	0
Jun	60.5	79.5	41.5	173	39	102	25	30	09	5	0	3	0	0.36	0.29	10				2	1	0
Jul	70.0	91.1	48.8	6	161	99	06	42	16	21	0	0	0	0.00	0.00	26				0	0	0
Aug	69.3	91.2	47.5	18	153	101	28	39	26	17	0	0	0	0.30	0.27	11				3	1	0
Sep	59.2	77.3	41.2	226	53	99	02	29	24	8	0	4	0	0.43	0.26	20				3	2	0
Oct	45.7	62.3	29.1	597	0	76	06	14	31	0	0	22	0	0.52	0.21	13				5	2	0
Nov	40.0	51.5	28.6	749	0	67	23	13	04	0	0	21	0	0.47	0.12	09				8	2	0
Dec	28.3	40.1	16.5	1137	0	62	29	4	12	0	8	31	0	0.12	0.06	24				3	0	0

Notes

(Blank)	Data element not reported or missing.	A	Accumulated amount.	T	Trace Amount.
+	Occurred on one or more previous dates during the month. The date in the Date field is the last day of occurrence.	X	Monthly means or totals based on incomplete time series.		

Deschutes County Property Information - Dial

Overview Map

Deschutes County GIS, Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map and Taxlot: 1513000000116

BULLETIN 89 TEXT

GEOLOGY AND MINERAL RESOURCES

OF

DESCHUTES COUNTY, OREGON

1976

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
R. E. CORCORAN, STATE GEOLOGIST

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
1069 State Office Building, Portland, Oregon 97201

BULLETIN 89

GEOLOGY AND MINERAL RESOURCES OF DESCHUTES COUNTY OREGON

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1976

1859

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GEOLOGY AND MINERAL RESOURCES OF DESCHUTES COUNTY, OREGON

INTRODUCTION

Purpose and Scope of Report

The importance of low-cost industrial minerals, such as sand, gravel, and building stone, close to growing communities is generally overlooked. As a result, urban encroachment on land underlain by these materials is a growing problem. Recognition of this problem by Deschutes County planners and other concerned persons in the County led to the request that the Oregon Department of Geology and Mineral Industries prepare a survey and evaluation of the County's industrial mineral resources. The following report is the outcome of that request.

Industrial mineral deposits are natural concentrations of useful and economically valuable rock materials. Because such deposits are directly related to the geologic history of an area, any in-depth discussion of them should include information on their origin, distribution, and relationship to rock units. Such information is of particular value to those charged with the responsibility of land use planning. For this reason we have described the geology of Deschutes County in some detail.

Three geologic maps illustrate the distribution of the rock units with which the mineral resources are associated. A colored geologic map shows the geology of Deschutes County at a scale of 3 miles to the inch. Two maps in black and white show, on a larger scale, the geology of the urban areas of Bend and Redmond, where land use planning is most critical. A mineral resources map shows the location of pits and quarries where industrial minerals are mined. Pertinent data for each site are given in the Appendix.

The field work and mapping for this project were done during the field season of 1974 and all available geologic maps and texts on the region were used in preparing this report. The geologic map of the Redmond area was modified from Stensland (1970 [revised in 1974]). The areas of previously published mapping are outlined on the County geologic map, and known available published references used in preparing the maps and writing the report are listed alphabetically in the Bibliography at the end of the text. Except for the chapter on geothermal resources, which was written by E. A. Groh, the text is the responsibility of N. V. Peterson. E. M. Taylor is responsible for much of the mapping in the northwest part of the County.

Acknowledgements

The authors are grateful to the many people, agencies, and organizations who provided information, technical assistance, and helped in other ways to make this report possible.

Mr. Lorin Morgan, Deschutes County Planning Director representing Deschutes County, helped to plan the project, and provided base maps and other information. Dennis Larson and Larry Chitwood, resource geologists of the Deschutes National Forest, provided information about industrial mineral deposits and were helpful in discussions of geologic problems. Roland VanCleve of the Oregon State Highway Department, and Charles Plummer and Don Scholes of the Deschutes County Road Department also furnished information about the production and source of road-building materials in the County. Bill Miller, formerly a member of the Governing Board of the Oregon Department of Geology and Mineral Industries, was helpful in planning the project and provided information about mineral resources. Robert Coates, Jim Curl, Chuck Clark, and Robert Johnnie also provided information about the production, location, and reserves of their industrial mineral resources.

Harry Metke of the Bend Water Department furnished well logs. Don Anderson, Jim McNeely, and Leroy Fox provided historical information and photographs of early-day mineral production in the County. Norman MacLeod of the U. S. Geological Survey provided preliminary age dates of rock units and freely discussed geologic problems of the area. We also benefited from field conferences with Bruce Nolf of Central Oregon College and "Mr. Central Oregon Geology" himself, Phil Brogan. Peggy Sawyer and the others at the Bend Chamber of Commerce as usual always cheerfully took care of our unusual requests.

Finally, the entire staff of the Oregon Department of Geology and Mineral Industries provided the moral support, editing, cartography, and other myriad details to make this a finished product.

Location, Accessibility, and Culture

Deschutes County lies just west of the center of Oregon (Figure 1); its interesting shape is like a giant ski boot with the toe pointing eastward and the heel at the west, outlined by the crest of the Cascade Mountains. Deschutes County, established in 1916, contains about 3,060 square miles (7925 km^2). Bend is the County Seat.

The County is crossed from northwest to southeast by U. S. Highway 20 and from north to south by U. S. Highway 97, which connects the Columbia River area on the north with Klamath Falls on the south. State Highway 126 and 242 cross the north part of the County and in summer furnish access to the Willamette Valley. A network of County, U. S. Forest Service, and private logging roads gives access to most other parts of the County. Among these is Century Drive, a paved loop road that provides a winter route to the popular ski area at Bachelor Butte and a summer route to numerous lakes and recreation areas in the southwest part of the County.

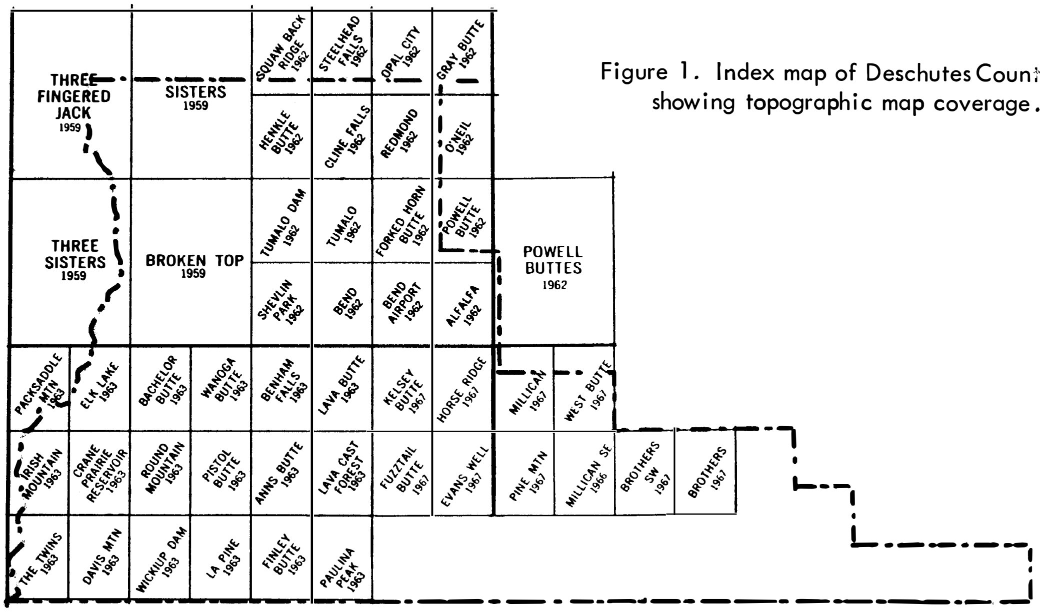


Figure 1. Index map of Deschutes County showing topographic map coverage.

Burlington Northern and Union Pacific rail lines provide daily service to the County, and the City of Prineville owns and operates a railroad that connects Redmond with Prineville. Roberts Field (Bend-Redmond Airport) at Redmond, provides scheduled airline service, and the Bend Municipal Airport serves small aircraft.

Pacific Power and Light Co. furnishes the area's electricity, and Cascade Natural Gas Co. brings in natural gas from a pipeline paralleling U. S. Highway 97.

Urban areas obtain domestic water from Tumalo Creek and the Deschutes River, and outlying areas tap the ground-water supply by means of wells. Most of the available surface-water supplies south of Redmond have been appropriated, so any new water supplies will have to be developed from the ground water.

Population density of the County as a whole is about 12 persons per square mile (2.6 persons per km^2). Total population and estimated future growth trends are shown in Figure 2. Most of the residents live in the north part of the County in and around the population centers of Bend (16,000), Redmond (5,000), and Sisters (600). From 1960 to 1970 Deschutes County was the fifth fastest growing county in Oregon, and since 1970 this rate of growth has increased even more, mainly in the suburban and outlying areas.

The Bend Chamber of Commerce reports, "The recreation development has been most dramatic in Deschutes County, where between 1960 and 1970 the rural population increased by 66 percent, while Bend grew by 10 percent. Developments are springing up all along the Deschutes River, ranging from simple plots of land in the woods (Figure 3) to large planned developments like Sunriver and Black Butte Ranch. Continued growth appears certain; some 15,000 lots are presently sold but unoccupied, and sales continue at a rapid rate."

A diversified economy is typical of Deschutes County, and even though timber, agriculture, and livestock raising continue to be the most important industries, forest product remanufacturing and recreation are rapidly expanding. The County has some of the most popular year-round recreation areas in the Pacific Northwest. The ski area at Mt. Bachelor is nationally known and is the center for a variety of winter recreation activities. In the summer, fishing in the numerous lakes and streams is very popular and the overall scenic beauty of the western half of the County attracts campers and hikers.

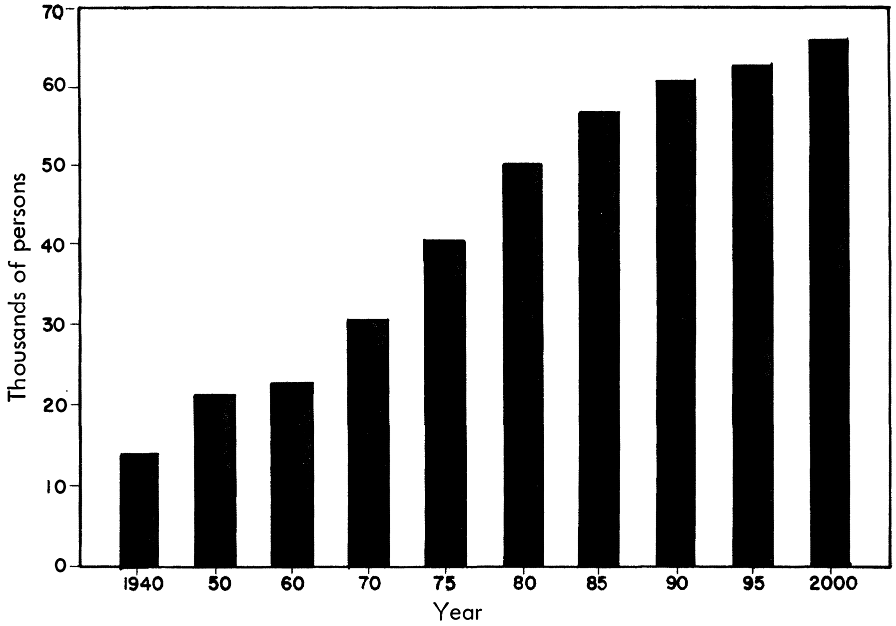


Figure 2. Population trends and projected population growth in Deschutes County. Projections for the years 1980 through 2000 from Center for Population Research and Census, Portland State University.

Figure 3. The juniper-rimrock landscape of central Oregon is changing rapidly as houses, such as these along the Deschutes River north of Tumalo, become more numerous.

Climate and Topography

The High Cascades form a definite weather barrier. Precipitation reaches 100 inches (250 cm) in the High Cascades and gradually decreases eastward to less than 10 inches (25 cm) in the High Lava Plains east of Bend. Most of the precipitation is winter snow; in summer there is only an occasional thunder shower. The temperature at Bend averages 47.5° F (8.6° C), but ranges as high as 105° F (40.5° C) in summer and as low as -25° F (-59° C) in winter. The short summer season (only about 120 frost-free days) limits agricultural crops to the hardiest varieties, such as alfalfa, grain, and potatoes.

The topography of Deschutes County ranges from over 10,000 feet (3,050 m) in the majestic peaks of the High Cascades to a general elevation of about 4,000 feet (1,200 m) in the broad area of the High Lava Plains extending eastward beyond the County boundaries. This wide variation in altitude, as well as in precipitation, results in great diversity of vegetation. The foothills and lower elevations of the High Cascades are thickly timbered with fir, hemlock, and pine (Douglas fir, Western white fir, Lodgepole pine, and Ponderosa pine). By contrast, the vegetation in the High Lava Plains in the eastern part of the County changes eastward from Ponderosa pine and Lodgepole pine to Juniper, sagebrush, and rabbit brush. Bunchgrass and planted grasses, such as crested wheat grass, give this part of the High Lava Plains some value for cattle grazing.

The northward flowing Deschutes River divides the County into distinct physiographic provinces. West of the river are the foothills and towering peaks of the High Cascade Mountain Range. East of the river is the gently undulating lava-covered plain, where no distinctive drainage pattern has yet been developed. The northern part of the High Lava Plains slopes gently northward; and here the Deschutes River and its tributaries have steep-walled canyons in the flat-lying lavas and sedimentary materials. Crooked River, one of the largest of the Deschutes tributaries, crosses the extreme northeast corner of the County. South of Bend the High Lava Plains are dominated by the massive Newberry Volcano (8,010 feet) (2,440 m) which has had a complex eruptive history and now holds two large lakes within its summit caldera.

In the area between the Cascade Crest and Newberry Volcano, volcanic activity has greatly altered the course and activity of the Deschutes and Little Deschutes Rivers. From Benham Falls southward the streams meander and flow sluggishly because of numerous lava dams in that vicinity. The youngest dam of this kind was formed relatively recently by lava flows from Lava Butte. From Benham Falls northward the Deschutes channel is somewhat straighter, and the canyons are more deeply incised; but even here older ash flows and lava flows have filled ancestral canyons and have forced the river to cut new channels.

Deschutes County could perhaps be called "the land of a thousand volcanoes." More than 500 large volcanoes, cinder cones, or volcanic vents can be counted on the geologic map, and probably that many or more are obscured by erosion and later sedimentary and volcanic cover. It is likely that Deschutes County contains a greater abundance and variety of volcanic landforms than any other area of similar size in the United States. For anyone interested in volcanoes and their products, Deschutes County is an outdoor classroom.

SUMMARY OF GEOLOGIC HISTORY

Origin of the Rocks

The geologic history of Deschutes County is one of recurrent episodes of volcanism that can be traced back nearly 40 million years to early Tertiary time (see time chart on County geologic map). Rocks of early Tertiary age occur in small outcrops along the eastern and northern borders of the County and more extensively in counties to the north and east. To the south, in Deschutes County, early Tertiary rocks may lie at depth beneath younger volcanic and sedimentary materials.

The oldest of the Tertiary rocks, which originated during a period of intense volcanism in late Eocene to early Oligocene time, are part of the Clarno Formation. They consist of weathered reddish brown andesite and basalt flows with interbedded layers of tuff and breccia. Vents for the volcanic eruptions have been obscured by erosion and subsequent tectonism.

The next episode of Tertiary volcanism, which occurred in late Oligocene to early Miocene time, produced the more siliceous explosive and effusive materials of the John Day Formation. The flow-banded rhyolite and ash-flow tuff that make up the spectacular erosional spires and pinnacles at Smith Rocks and Coyote Butte are thought to be remnants of these violent eruptions, with Gray Butte to the northeast as a possible volcanic vent. Cline Buttes near Redmond is also assumed to be a John Day volcano.

Later, during the Miocene epoch, large volumes of basaltic lava, known as the Columbia River Group, covered much of northeastern Oregon, reaching the northeastern edge of Deschutes County. Here, along Bear Creek, a few of the Miocene lava flows overlie the eroded massive layers of varicolored tuffs of the John Day Formation. Late Miocene sediments overlying the gently deformed basalt of the Columbia River Group may represent the Mascall Formation.

Gradual regional subsidence began in central Oregon in early Pliocene time and was accompanied by widespread and varied volcanic activity which produced a heterogeneous assortment of thin basaltic lava flows, ash-flow tuffs, ash falls, and volcanic detritus. Pliocene-age materials were distributed widely in the central and northern part of the County, where they accumulated as a flat-lying unit hundreds of feet thick, known as the Deschutes Formation. Sedimentation and minor sporadic volcanism continued into the Pleistocene.

The latest period of intensive volcanic activity in Deschutes County began along the north-south alignment of the Cascade Range, also at Newberry Volcano, and at isolated locations like Grassy Butte in the east part of the County. Earlier workers believed that the broad High Cascades platform with its crowning peaks began to build in Pliocene time, but Taylor (1968) now suggests that the High Cascades are entirely of Pleistocene and Holocene age. McBirney (1969) and McBirney and others (1974) have confirmed that even the largest central Cascade volcanoes, including the Three Sisters, Bachelor Butte, Broken Top, and the adjacent Newberry Volcano, were built within the last million years. Basalt was the most common material erupted during this latest volcanic episode, but numerous ash falls and ash flows erupted from silicic centers near Broken Top, South Sister, and also from Newberry Volcano. Obsidian domes within Newberry Volcano are as young as 1,200 years; and the most recent basaltic lava flows from vents on the north flank of North Sister are only a few thousand years old. In view of this recent activity it is surprising that no historic volcanic eruptions have occurred, and it is interesting to speculate where the next eruption might take place.

The High Cascade peaks and their flanks have been deeply scarred by the erosive forces of Pleistocene glaciers. A few small remnants of the former large glaciers and ice fields are still present (Figure 4). Prominent terminal moraines mark their latest advance and retreat. Outwash sand and gravel from their meltwaters fill ancient channels and form broad fan-shaped deposits at lower elevations.

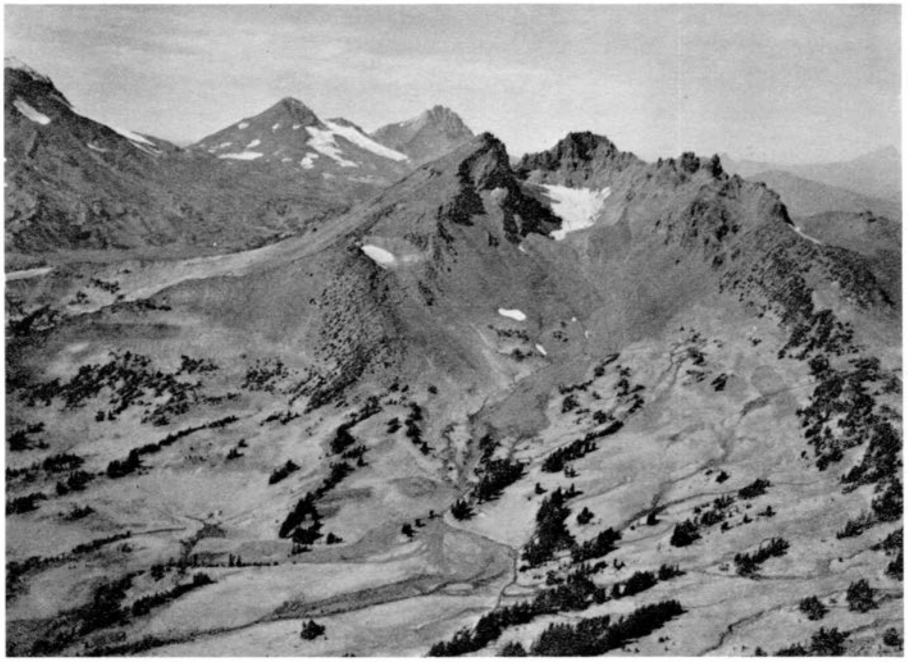


Figure 4. This late summer view of Broken Top and the Three Sisters shows the remnants of the once extensive glaciers that eroded the High Cascade peaks during the Pleistocene.

Structural Events

Evidence from rocks exposed in Deschutes County and in surrounding areas indicates moderate folding and faulting of the Clarno Formation in Oligocene time, minor folding of the John Day Formation and Columbia River Basalt in Miocene time, and, finally, erosion of the region to one of moderate relief. The general horizontal attitude of the Deschutes Formation and other post-Miocene units shows that folding had ceased by late Cenozoic time.

In early Pleistocene, Deschutes County began to be the focal point for three major styles of crustal activity, some of which continued on into Holocene time.

One of these was a northwest-trending zone of en echelon faults that extended across the entire County. This feature, the Brothers fault zone, is interpreted to be part of a regional zone of crustal weakness along which minor faulting has offset all units older than late Pleistocene.

A second kind of Pleistocene activity was the construction and destruction of Newberry Volcano, which grew into a huge shield-shaped mass and then collapsed along large concentric fractures, forming a caldera as magma drained away. In Holocene time, fractures on the flanks of the volcano provided escape for the extensive lava extrusions such as the "Lava Badlands" and the pyroclastic eruptions such as Lava Butte. Fractures within the caldera were the locales for the eruption of silicic domes and flows of obsidian.

A third type of crustal activity was the development of a north-trending deep-seated structural lineament and the eruption along it of the High Cascade volcanoes previously described.

In historic time, Deschutes County has been relatively quiet in a geologic sense, indicating that crustal movement and volcanism are dormant.

DESCRIPTION OF GEOLOGIC UNITS

The geologic units described in this section of the report are presented in chronological order in so far as this is feasible. Many of the younger units overlap in time because they represent nearly simultaneous volcanic eruptions and accumulations in different places. Even though similar in age, the units are sufficiently distinctive in composition to be given lithologic names and be mapped. Letter symbols following the name of each unit appear on the geologic maps as an aid to reading the maps.

Following the description of each unit is a brief summary of the associated mineral resources; fuller discussion can be found in the section titled "Mineral Resources."

Pre-Pliocene Rocks (Tpp)

The pre-Pliocene rock unit in this report includes all rocks of Eocene, Oligocene, and Miocene age. This unit is exposed in several small isolated areas of Deschutes County as follows:

In the northeast corner of T. 20 S., R. 19 E., about 10 miles north of Hwy 20 northwest of Hampton Buttes, the rocks are mainly andesite flows, breccias, and interbedded tuffaceous sedimentary rocks that were correlated by Walker and others (1967) with the Clarno Formation of Eocene-Oligocene age. The original andesite flows are now altered to greenish-gray amygdaloidal rocks which typically weather to irregular fragments with coating of red-brown in a reddish-brown soil. Agate, jasper, and fossil wood occur in similar rocks to the east on the flanks of Hampton Buttes.

In the northeast corner of T. 14 S., R. 13 E., at Smith Rocks, Coyote Butte, and a small isolated outcrop south of Terrebonne, there are erosional remnants of thick ash flows, rhyolite flows, and silicious pyroclastic rocks of the John Day Formation. The dominant rocks in the Smith Rocks State Park are platy, mottled tan to red rhyolite flows and ash-flow tuffs. Differential weathering of variably silicified tuffs and devitrified rhyolite flows partially accounts for the curious erosional land forms (Figure 5). The Crooked River has also had a part in undercutting and eroding the spires and pinnacles as it was dammed and forced northward by encroaching basaltic lava flows from the south.

In the northeast corner of T. 19 S., R. 16 E., northeast of Millican in the upper reaches of Bear Creek, the pre-Pliocene rocks include basalt flows of the Columbia River Group (Walker, 1967). In this area several flow units of the typical thick columnar jointed dense black basalt flows that weather to a reddish-brown color and litter the slopes with thick talus, are present. Walker correlates this part of the Columbia River Group flows with the Picture Gorge Basalt and these exposures may be the southernmost of the typical Columbia River Group in central Oregon. Above the basalt flows in this area are tuffaceous sedimentary rocks, "Tts" of Walker and others (1967), that are light colored, poorly bedded tuffaceous sediments of flood plain or shallow lake origin. These are believed to be correlative with the Mascall Formation, a part of the Columbia River Group of late Miocene age.

Two other notable occurrences of pre-Pliocene rocks are in the north part of the County. Their age is speculative. Stearns (1931) described a large mass of eroded andesite covering several square miles and straddling the border between Deschutes and Jefferson County on the west bank of the Deschutes River. Forked Horn Butte southwest of Redmond is also composed of this characteristic porphyritic andesite vitrophyre. Stearns suggested that this rock type originated with the older andesites of the Cascades and he assigned it a Miocene (?) or Pliocene (?) age. Stensland (1970) correlates the andesite vitrophyre with rocks of Clarno age. As Stearns noted, the age of the andesite remains unknown, but it is separated from the overlying horizontal beds of the Pliocene Deschutes Formation by a steep erosional unconformity.

The pre-Pliocene rocks generally do not appear to contain any notable mineral resources. However, small quantities of the silicified tuffs near Terrebonne have been quarried for building-stone. Basalt of the Columbia River Group and the andesite vitrophyre described above could provide crushed rock where sand and gravel are not conveniently available.

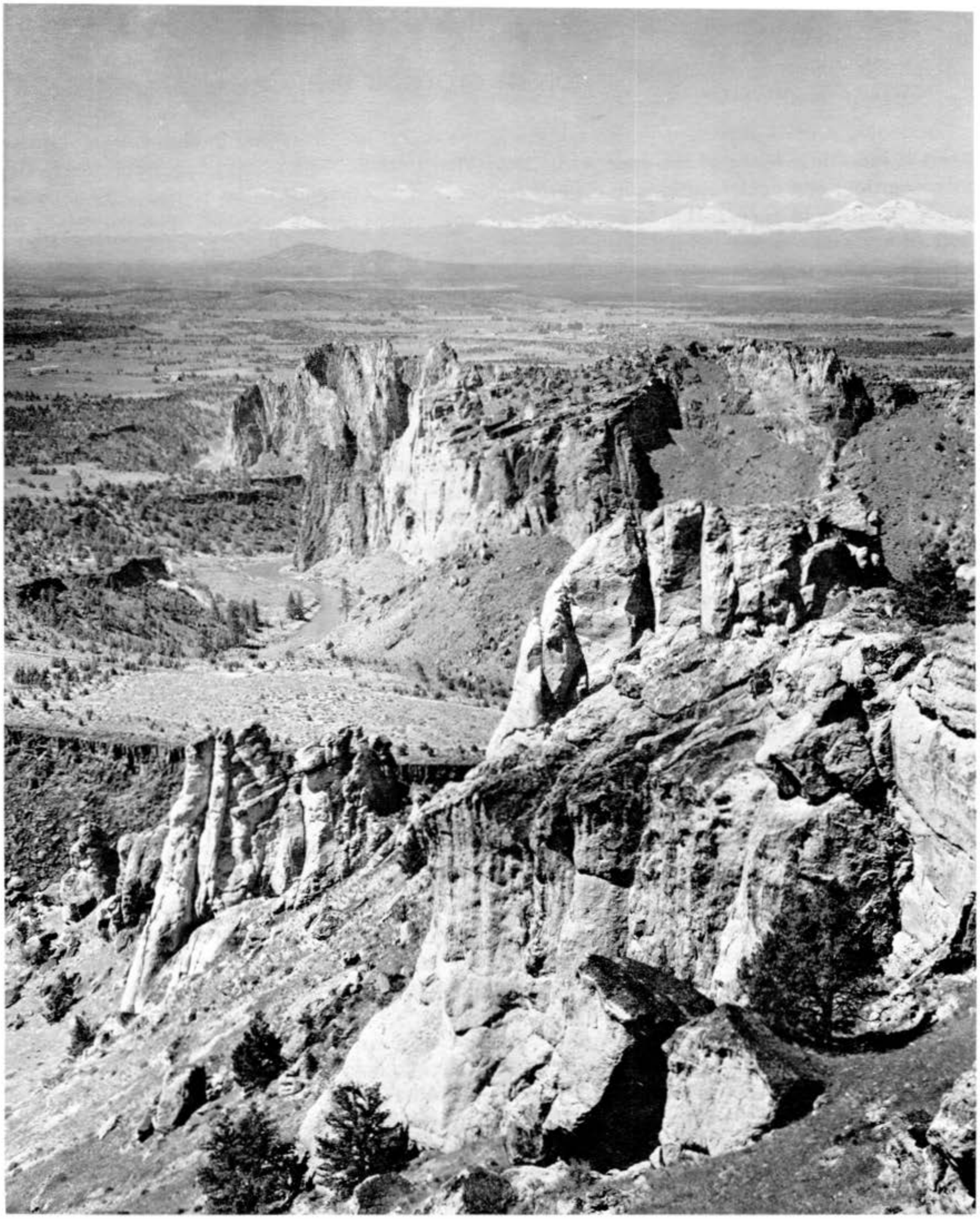


Figure 5. View from Smith Rocks looking southwest across the central Deschutes River basin. Smith Rocks are the erosional remnants of a John Day age (Oligocene) volcanic center composed of rhyolite domes and ash-flow tuffs. Lava at the base of Smith Rocks flowed from the north flank of Newberry Volcano and forced Crooked River against Smith Rocks. Cline Buttes, another rhyolite volcano of John Day age, is in the middle distance. The snow-covered peaks of the High Cascades in the distance mark the western boundary of Deschutes County. (Oreg. Hwy. Div. photo 6068)

Pliocene Rocks

Tuffaceous sandstones (Tst)

Tuffaceous sandstones and siltstones occur in irregular patches along the northeastern boundary of the County. The sediments are thinly layered, partially consolidated, and commonly tan to light brown. They appear to have been deposited in a fluvial, flood plain, or shallow lake environment. Outcrops are scarce and areas underlain by the Tst unit usually exhibit a subdued topography. The unit is believed to be of early to mid-Pliocene age.

Some lenses of sand and gravel occur in the Tst unit. Small amounts have been used for road buildin and maintenance northeast of Brothers, but the supply appears to be limited.

Ash-flow tuffs (Twt)

Densely welded portions of ash-flow tuffs interfingering with the tuffaceous sandstone (Tst) are preser in irregular patches on the south and west flanks of Hampton Buttes in the eastern part of the County. The ash-flow tuffs are gray to reddish and probably consist of more than one unit. Walker (1970) describes one thin, pumiceous ash-flow tuff that crops out extensively west of Hampton Butte along the Crook-Deschutes County line and states that it has been dated at 3.6 million years (late Pliocene). No mineral resources are known to be associated with the Twt ash-flow tuffs.

Basalt (Tb)

The unit is composed of thin flows of medium to dark-gray olivine basalt, generally with diktytaxitic textures. The basalt is commonly vesicular and has secondary fillings of opaline silica. A thin soil covers the top flow, and no initial surface structures are preserved. South and east of Hampton, fault blocks show multiple thin flows totaling at least 100 feet (30 m) thick (Figure 6).

In the Bear Creek Buttes and on the eastern flank of Pine Mountain, the Tb basalt is the predominant rock type. On the west flank of Bear Creek Butte, in the Highway 20 roadcuts, the flows alternate with agglutinate and cindery debris and are apparently near their source. At the Horse Ridge summit, the steep canyon walls of Dry River and the highway roadcuts expose the numerous thin scoriacious basalt flows and alternating cindery breccia, ash, and agglomerate layers and show the complex buildup of the rounded volcanic landforms of Bear Creek Buttes and Horse Ridge. East of Bear Creek Buttes the Tb basalt overlies the Tst sediments of late Miocene age and is difficult to differentiate from the overlying QTb unit. No known age determinations are available, but the Tb lava flows are generally believed to be Pliocene in ag

Small quarries for crushed rock have been opened in the Tb basalts; however, the thinness of the flow and the lack of closely spaced jointing precludes development of large tonnages at any one location.

Pliocene-Pleistocene Volcanic Rocks

There are literally hundreds of eruptive centers in the County ranging in size from small spatter or cinder cones to voluminous volcanic piles such as the majestic High Cascade stratovolcanoes. Many of the large eruptive centers in the east and north, such as Pine Mountain, Frederick Butte, and Cline Buttes, contain rock types ranging from rhyolite to basalt and have a complex eruptive history. The larger peaks in the High Cascades, with the exception of Middle and South Sister, are predominantly basaltic. Middle and South Sister are two of those that exhibit an especially complex volcanic history involving both flow and pyroclastic rocks that range from rhyolite to basalt. The shield volcanoes and smaller vents, including the cinder cones, have a simpler volcanic history and usually contain only a single rock type.

Silicic vent rocks (QTsv)

Predominantly rhyolite to dacite lavas make up Pine Mountain, Frederick Butte, and Cline Buttes.

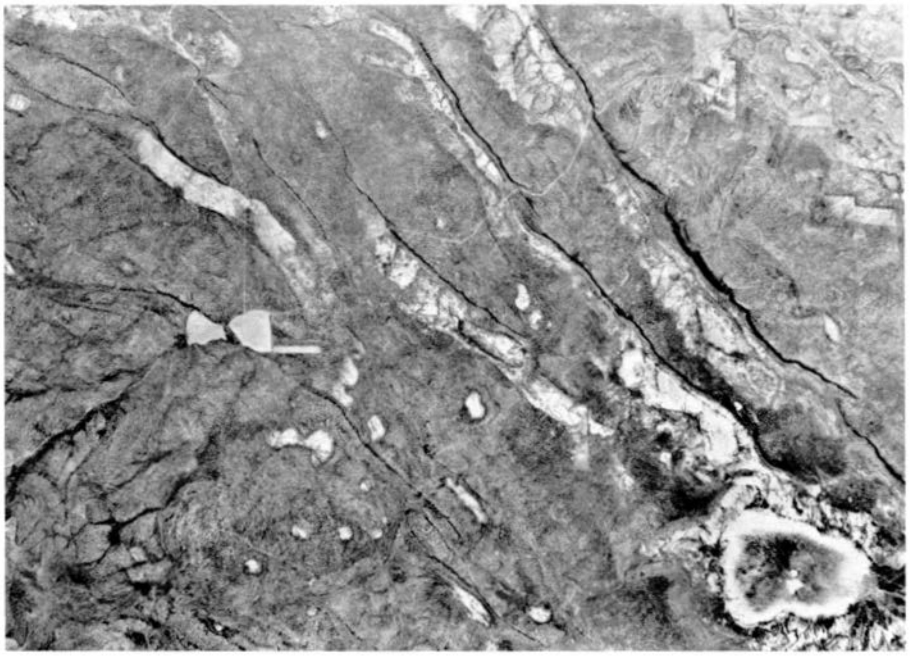


Figure 6. High elevation aerial view of parts of T. 22 S., Rs. 20 and 21 E. in eastern Deschutes County. The Brothers fault zone offsets lava flows of the Tb and Qtb units, forming northwest-trending fault blocks and intervening valleys with interior drainage.

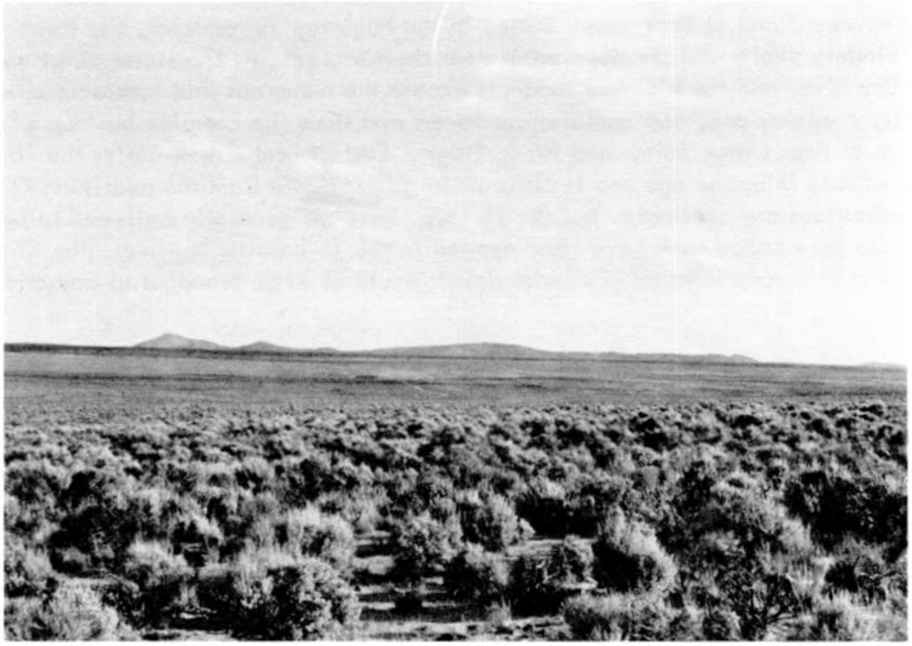


Figure 7. Frederick Butte, about 10 miles south of U.S. 20. The outcrops form a semicircular volcanic feature interpreted to be a large caldera-like structure.

We are not aware of any absolute dates for Pine Mountain or Cline Buttes, but both show considerable erosion and are covered with thick soil zones. The light-gray, flow-banded rhyolites and rhyolite breccias suggest that Cline Buttes is part of a formerly larger complex of intrusive-extrusive domes; Williams (1957) suggests that Cline Buttes is of John Day age, and its composition and position not far from outcrops of known John Day rocks to the northeast makes this a reasonable suggestion. Pine Mountain is predominantly rhyolite and dacite vitrophyre, both massive and flow banded. It also contains thick basaltic flows on its northeast flanks and obviously has a complex eruptive history. Its soil cover and state of erosion indicate that it also may be of John Day age; however, Walker and others (1967) consider it of Pliocene age.

The outcrop pattern at Frederick Butte suggests that it could be the north half of a fairly large caldera (Figure 7). This roughly ring-shaped mass is predominantly flow-banded rhyolite-dacite with a few dikes and minor flows of basalt. A potassium-argon age date by Walker (1974) gives a 3.9 ± 0.4 million year age for rhyodacite from Frederick Butte, indicating volcanic activity in late Pliocene time. Since its last volcanic activity, Frederick Butte has been eroded, faulted, and all but inundated by Plio-Pleistocene basaltic lava flows which now surround it.

Another east-west trending ridge or dome complex of medium gray flow-banded dacite of uncertain age is situated at Benham Falls south of Bend. This resistant rock forms Benham Falls and forces the Deschutes River to make a wide loop around it. Ash-flow tuffs (Qwt) lap around this dome complex indicating that it must be at least as old as late Pliocene. A preliminary potassium-argon age date of 2 to $2\frac{1}{2}$ million years has been reported by MacLeod (personal communication, 1976).

A quarry has recently been opened on the east flank of Cline Buttes where flow-banded rhyolite and breccia are being crushed for use in the construction industry. Zones of perlite were also noted in the Cline Buttes complex, but the quality and quantity are not known. There are probably sites on Pine Mountain where large quantities of crushing rock could be developed; however, its remoteness from markets is not encouraging. The geothermal potential near the large silicic vents is still to be determined.

Mafic vent rocks (QTmv)

The basaltic eruptive centers occur generally in two roughly aligned belts which reflect the major structural lineaments in the County. In the eastern part of the County the larger basaltic eruptive centers are roughly aligned northwesterly along the Brothers fault, and prominent vent areas include the Bear Creek Butte and Horse Ridge. Along this same trend in the Bend-Redmond vicinity, Aubrey Butte, Overturf Butte, Tumalo Butte, Long Butte, and Laidlaw Butte are some of the prominent features. At the very north edge of the County the symmetrical Black Butte volcano straddles a prominent fault of the Brothers fault zone, which here veers northward.

Of the spectacular stratovolcanos along the Cascade Crest, Mt. Washington, North Sister, and Broken Top are all predominantly of basaltic composition. Of the many large steep-sided shield type volcanos on the east flank of the Cascades, Davis Mountain, (Figure 8), Brown Mountain, Maiden Peak, Cultus Mountain, and The Twins appear to be randomly distributed while others like Bachelor Butte, Sheridan Mountain, Lookout Mountain, Round Mountain are parts of aligned chains of volcanos that form impressive north-south masses paralleling the High Cascades. Many have been glaciated severely and their central plugs are exposed, while others like Bachelor Butte and Black Butte show only minor glacial scarring and still retain their symmetrical constructional shapes.

The mafic volcanic vent rocks are far from homogenous. They consist of lava flows and a great variety of pyroclastic material, including cinders and scoria. Layered tuffs, breccias, and mud-flow debris are commonly exposed in the large volcanic piles.

Most of the basaltic volcanic vent areas in the eastern part of the County appear to have been considerably eroded and may be as old as Pliocene. Most of those in the triangle between the High Cascades, Newberry Volcano, and the Deschutes Basin retain their original constructional landforms and probably range from Pleistocene to Holocene in age.

Cinders have been quarried from many of the large basaltic centers such as Davis Mountain, Lookout Mountain, and Round Mountain. These vent areas will continue to be sources of cinders and scoria for local road building.

Figure 8. View across Wickiup Reservoir toward Davis Mountain, one of many shield volcanoes in southwestern Deschutes County.

Figure 9. Wake Butte is an elongate erosional remnant of a tuff ring complex of probable Pliocene age. Photo shows the eroded edges of thin layers of palagonite tuff.

Figure 10. View of Lava Butte cinder cone from the south side showing the crater in the top and the vent and gutter at the base from which lava flowed around the cone and westward toward the Deschutes River.

Pyroclastic rocks (QTp)

Cinder-scoria cones and mounds, tuff rings, and basaltic tuff cones are closely associated with the previously described basaltic eruptive centers, and there are hundreds of these smaller explosive volcanic landforms. They range from older eroded tuff-ring deposits of Pliocene age, such as those at Wake Butte (Figure 9), to the symmetrical cratered cones like Lava Butte (Figure 10), which is only a few thousand years old. Many north-south aligned pyroclastic cones are concentrated on the east flank of the Cascades, and heavy concentrations can be seen on the north and south flanks of Newberry Volcano (Figure 11). North and South Twin Lakes, two of the many interesting small volcanic features, are true maars (lake-filled explosion craters).

The tuff ring and maar-type features result when a rising basaltic magma encounters water or water-saturated materials near the surface. The resulting violent eruptions generate fine ash and rock fragments that are thrown high into the air and then settle to form the typical thin layers of basaltic tuff that build up around a broad cone-shaped crater. The tuff ring deposits are composed of a variety of volcanic rock fragments in a matrix of fine frothy basaltic glass. Their colors range from gray to drab yellows and browns. Peterson and Groh (1963) have discussed the maars of south-central Oregon in detail.

Figure 11. View east from Abbot Butte toward the gently sloping north flank of Newberry Volcano showing some of the many Pleistocene and Holocene cinder-scoria cones that dot the surface.

Figure 12. Deschutes Formation exposed in the Deschutes River canyon in sec. 16, T. 16 S., R. 12 E., west of Long Butte. Massive upper layer is tan to light gray pumiceous ash-flow tuff. Lower layers are sand, gravel, and ash. A northwest-trending fault locally controls the direction of the river channel.

The numerous cinder and scoria cones in Deschutes County are also basaltic in composition. Most were built over vents by fire fountaining, a less violent eruption than the maar type. During fire fountaining, molten clots of lava shoot out of the vent to heights of a few hundreds of feet and shower down around the vent in a conical mound of bombs, lumps of scoria, cinders, and ashes. Typical cinder cones such as Lava Butte or Pilot Butte are 400 to 600 feet (120 to 180 m) high and 2,000 to 5,000 feet (600 to 1,500 m) across at their base. Many of the simple cones have well-developed central craters, while others have broad rounded tops. Many of the cones also exhibit breached craters where later eruptions of lava have rafted away parts of the cinder cone or scoria slopes (Figure 10).

The palagonitic material (altered volcanic glass) of the tuff rings has no known economic value, but the cinder cones furnish a major portion of the cinders and scoria for the road building and construction industry in the County. Details about the composition and texture of the cinders and scoria are discussed in the mineral resource section of the study.

Deschutes Formation (QTd)
[(QTds) on Redmond map]

The name Deschutes Formation was first used by Russell in 1905 for fluvial and lacustrine volcaniclastic sediments in the Bend - Madras area; so this name has historical priority, even though later writers have called the unit the Madras Formation and the Dalles Formation.

The Deschutes Formation is a heterogeneous assemblage of basaltic tuffaceous sediments, conglomerate, mudflows, silicic ash-flow tuffs, diatomite, and interbedded basaltic lava flows. The base is not generally exposed in Deschutes County; however, several hundred feet of the middle and upper parts of the formation are exposed in the Deschutes River Canyon, lower Squaw Creek, and Deep Canyon in the north central part of the County. Figure 12 shows a typical section of the thin- to thick-bedded siltstone, sandstone, and conglomerate with minor resistant ash-flow tuff layers.

Stensland (1970) describes the Deschutes Formation in great detail and assigns an early through late Pliocene age to the formation. He restricts the name to the sedimentary sequence beneath the conspicuous "rimrock" basalt (QTdb on Redmond map; QTb on County map) which forms broad plateaus and flat-topped ridges in the central and northern part of the County. Farther south and east in the Deschutes Basin, especially adjacent to the Deschutes River, younger ash-flow tuffs, basaltic lava flows, and interbeds of sand and gravel indicate a generally similar depositional environment and it appears that rocks similar to those of the Deschutes Formation have been accumulating more or less continuously to the present time.

A distinctive mudflow unit interlayered within the Deschutes Formation near Redmond is mapped separately by Stensland (1970) who calls it the "Tetherow mud-flow breccia." The unit has been noted by earlier workers, particularly Stearns (1931). The mudflow unit shown on the Redmond area map as QTdm is at least 100 feet (30 m) thick. It is exposed adjacent to and in the canyon of the Deschutes River near Tetherow Bridge west of Redmond and also just west of Forked Horn Butte. The unit weathers to low rounded hills and, in the canyon walls, to bold cliffs and "hoodoo" landforms (Figure 13). As Stensland indicates, this unit is generally composed of unsorted angular volcanic debris ranging from fine ash to large blocks as much as 10 feet in diameter. Composition of the fragments ranges from basalt to rhyolite with a predominance of the andesite vitrophyre like that which makes up Forked Horn Butte. The matrix is tan to pinkish, is distinctly tuffaceous, and contains small fragments of perlite and black glass. It is also micro-vesicular and somewhat altered to palagonite. The composition and texture indicate an explosive volcanic origin for the mudflow unit.

The upper part of the Deschutes Formation contains a large deposit of commercial-quality diatomite which has been mined from an area of about one square mile at Lower Bridge west of Terrebone. The relatively pure diatomite accumulated to a thickness of about 40 feet (14 m) in a spring-fed lake, probably as a result of a lava-dam of an ancient Deschutes River channel. This deposit is described in more detail in the mineral resource section of this report.

Diatomite and some sand and gravel from the conglomerate interbeds are the main mineral resource potential for the Deschutes Formation. Some of the ash-flow tuff layers may be suitable for use as building stone.

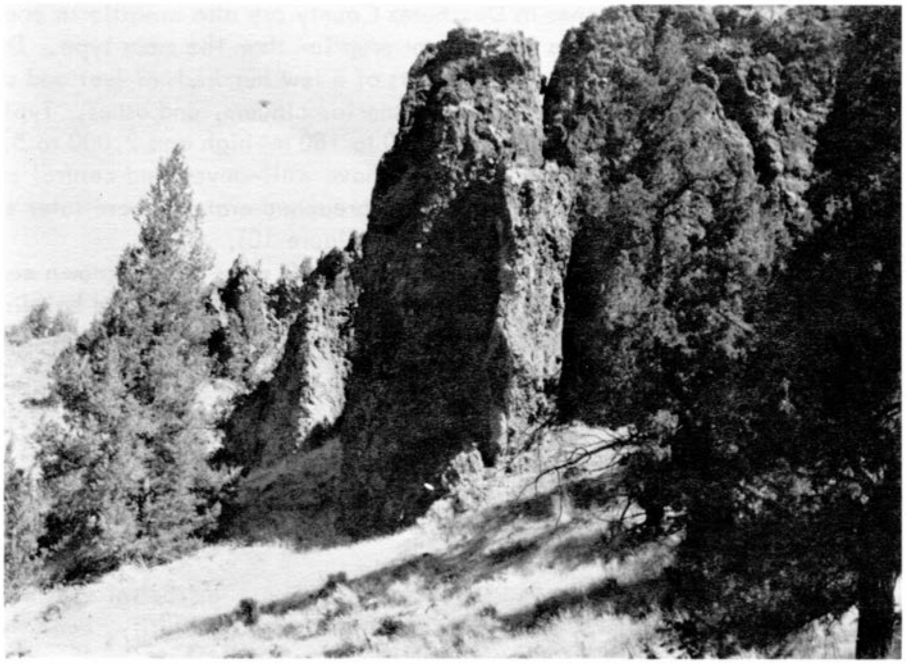


Figure 13. East wall of the Deschutes River canyon above Tethrow Bridge, west of Redmond, is composed of mud-flow breccia of the QTdm unit (Redmond quadrangle map) eroded to steep cliffs and small hoodoos.

Figure 14. Deschutes River canyon west of Canyon Drive. "Rimrock" lava of the QTb unit overlies and fills shallow erosional channels in layered sediments and ash-flow tuffs of the Deschutes Formation.

A study of liquid waste disposal in wells Sceva (1968) shows the Deschutes Formation to extend south and east of Bend beneath the cover of the extensive overlying basaltic lava flows. Sceva reports that in much of the County the regional water table is within the Deschutes Formation at a depth of 500 to 600 feet (150 - 180 m) below the surface and serves as a major source of ground water.

Pliocene - Pleistocene Basalt Flows and Dikes

Basalt flows (QTb) (QTdb, Redmond map)

Similar to the previously described Pliocene basalt flows (Tb), these flows are generally medium-gray to black, vesicular, and diktytaxitic. They are the predominant rock type in the eastern third of Deschutes County and also form the conspicuous and widespread "rimrock" basalt at the top of the Deschutes Formation in the northern part of the County (Figure 14). In both places the lavas flowed over areas of moderate relief, and the thicknesses of individual flows varies from 10 to 100 feet (3 to 30 m). Flow breccia is usually presen at the base of the flows, and rubbly and vesicular zones occur near the surface. Roughly developed columnar jointing is usually present. Original flow surfaces are sometimes recognizable, usually covered by only a thin layer of wind-blown cindery or pumiceous soil.

In the eastern part of Deschutes County tensional stresses associated with the Brothers fault zone have broken the flows into northwesterly aligned elevated blocks and intervening elongate valleys that usually have internal drainages and small dry lakes (Figure 6). Some blocks are slightly tilted, but most of the flows are horizontal. Nowhere does the displacement on the normal faults appear to be over 100 feet (30 m), and the sharply aligned fault escarpments can be easily seen in air photos of the area, indicating the recency of the faulting. The flows appear to be quite young, although this period of basaltic volcanicity may have persisted for quite a long time. Walker and others (1974) reports a potassium-argon age of 6.6 m.y. for the second flow from the top just east of Millican along U. S. Highway 20. Similar basalt flows lap around Frederick Butte, where rock from a rhyodacite dome is dated at 3.9 m.y. Sources for the basalt flows in eastern Deschutes County are not conspicuous but some flows appear to have originated from small eroded vent complexes such as Watkins Butte and K. O. Butte along the southern border of the County.

In the northwest part of the County, in the Bend-Redmond-Sisters triangle, the QTb "rimrock" basalt, is also faulted along the same northwest trending zone, although not nearly as intensely as in the eastern part of the County. Displacements are small and indicate tensional stresses with normal fault movement. The age range of these flows is perhaps not as great at that of the eastern flows, and individual flows appear to be generally thicker. Scoriaceous, rubbly zones are present at the bottoms and tops of the flows, and freshly broken surfaces show the light-to dark-gray diktytaxitic texture that is typical of so many of the Pliocene-Pleistocene basalt flows east of the Cascades. The typical irregular columnar jointing is poorly to well developed. Many of the vents for the "rimrock" basalt flows have probably been obscured by later volcanism, but it appears that early activity at mafic volcanoes such as Aubrey Butte, Overturf Butte, Laidlaw Butte and the faulted basaltic hills along U. S. Highway 20 between Tumalo and Sisters may have been their source.

The only mineral resource potential for the QTb basalt flows is for common crushed rock. The thinness of the flows, the presence of cindery interflow zones, and the lack of closely spaced jointing make crushing difficult, and sites for large quarries with sufficient tonnages are scarce.

Dikes

Only in a few places has erosion exposed narrow dikes and intrusive spines that mark the vents for lava flows or cinder-scoria mounds. The few that are shown on the County geologic map and the Redmond geologic map are long, narrow ridges of dense, fine-grained to porphyritic basalt which appear to be sources for the lava flows mapped as QTb in the northwest part of the County. Near Lower Bridge, northwest of Redmond, a relatively narrow ridge 80 feet (25 m) high is interpreted as a dike. It extends N. 10° W. for about half a mile (.8 km) from the Lower Bridge Market Road. A similar long, narrow basalt ridge is present in sec. 10, T. 17 S., R. 11 E., northwest of Bend. Another smaller elongate ridge about 2 miles (3.2 km) southeast of Sisters is probably a dike but is shown on the geologic map as a basaltic vent QTmv. The largest intrusive body is a wide mass or dike, exposed by erosion of Tumalo Creek, between Aubrey Butte and Tumalo Butte.

ZONE	IDENTIFYING CHARACTERISTICS
Black ash flow 0 - 20' thick 0 - 6 m	Prominently exposed in east wall of Tumalo Creek Canyon at Shevlin Park. Surface usually removed by erosion; in some places has a thin to thick layer of dark-gray ash with large black breadcrust bombs scattered through it. Upper to mid-parts are punky; dark gray, dark brown, to black, with scattered rock fragments of various colors. Lower part often intensely welded to glassy with elongate blebs of black glass common. Appears to be the youngest ash flow of the Qwt.
	Lenses of cindery sand and gravel at base of this ash flow.
Gray pumice ash flow 0 - 30' 0 - 9 m	Prominently exposed at Meadow Campground south of Bend in Deschutes River Canyon. Also occurs south and west of Bend. Generally is a gray to pinkish pumice-charged ash flow. Pumice fragments are altered to a reddish brown and are devitrified. Groundmass also shows some alteration, with small brownish specks disseminated throughout. Like the other ash flows, appears to have filled in low topography and in some areas is missing.
Zone of irregular induration	Where it can be recognized, this contact is concordant and thin with only a fine layer of pinkish ash.
Pink ash flow Tumalo 0 - 30' 0 - 9 m	Appears to be one of the most widespread. Can be seen in roadcuts surrounding Tumalo Park and is prominently exposed south of Bend. Groundmass pinkish to tan; distinctive tan to brown pumice fragments abundantly disseminated. Upper part of flow is irregularly hardened, and the thickness of the partly welded zone varies greatly over short distances. Where not welded and in the lower part it is punky to loosely indurated. Lower parts contain abundant large pinkish pumice fragments. In some areas erosion has removed nearly all of this ash flow.
	Contact easily recognized and marked by a thin layer of pink to grayish ash.
White pumice deposit 0 - 40' 0 - 12 m	Widespread in the area just south and west of Bend; also occurs in thick deposits near Tumalo and Laidlaw Butte. White to light-gray lump pumice. Minor amounts of ash and scattered small angular basalt and andesite fragments. Occurs as an essentially unsorted, compacted but non-indurated massive deposit; airlain, probably a glowing avalanche type deposit. Contains occasional charred wood fragments. Pumice fragments are unaltered and range in size up to 6 inches (15 cm) but average closer to 1/2 inch (1 cm). This is the marketable pumice of the Bend area.
	A few inches to a few feet of layered dark-gray to gray ash and rounded pumice fragments or dark-gray to black bombs usually present at this contact.
Brown to red-brown ash flow 0 - 40' 0 - 12 m	Perhaps the most widespread ash-flow tuff unit. Occurs prominently low in Deschutes River Canyon at Tumalo Park, along Highway 20 at Innes Market Road Junction, also low in west wall of Tumalo Creek Canyon in Shevlin Park. Usually tan to dark brown or reddish, with abundant volcanic rock fragments. Contains characteristic large lumps of black, porphyritic pumice.
	Base usually not exposed, but underlying units are assumed to be basaltic-andesite lava flows or sediments of the Deschutes Formation.

Figure 15. Stratigraphy and identifying physical characteristics of the Qwt ash-flow tuff. Oldest flow at bottom of column; youngest at top.

Pleistocene Ash-flow Tuffs and Pumice (Qwt)

Williams (1957) mapped and described a widespread welded dacite tuff of late Pleistocene age west and north of Bend, and also describeda glowing avalanche deposit of unconsolidated white and pink dacite pumice in the Tumalo Creek and Deschutes River canyons. Our field work in the area west and north of Bend shows that there are at least five distinctive ash-flow tuff units, including the thick deposit of unconsolidated white pumice. The age of the ash flows is not definitely known; the earliest unit may be as old as latest Pliocene, with the latest unit early to mid-Pleistocene. All appear to have been erupted during an episode of explosive volcanic activity in the Broken Top - South Sister area. Even though this explosive activity was relatively brief, there was enough time between eruptions for erosion channels and thin sedimentary deposits to develop on most of the ash-flow units. It was not the intent of this study to map the extent of each ash-flow unit, so they are all included under the symbol Qwt on both the County geologic map and the Bend map. Figure 15 is a generalized stratigraphic column showing the sequence of ash-flow tuffs with their identifying characteristics. A separate study of the ash-flow tuffs west of Bend is being completed by E. M. Taylor of Oregon State University. Taylor's study will show the areal extent of the individual flows and describe them in detail.

Newberry Volcano has also been a source of ash-flow tuffs and has two distinctive dark-colored andesitic (?) ash-flow units on its flanks. On the northeast flank a dark-brown to reddish-orange, punky to partially welded ash-flow tuff can be traced over several square miles. Excellent exposures as much as 25 feet (8 m) thick can be seen in the SW¼ sec. 26, T. 20 S., R. 14 E., where Teepee Draw and other northeast trending drainages cut through the ash-flow unit (Figure 16).

Although the Qb flows from the north flanks of Newberry Volcano have not been mapped separately in this study, three ages can be recognized in the field by slight differences in vegetation, weathered surfaces, and soil cover; the oldest flows are slightly offset by faulting.

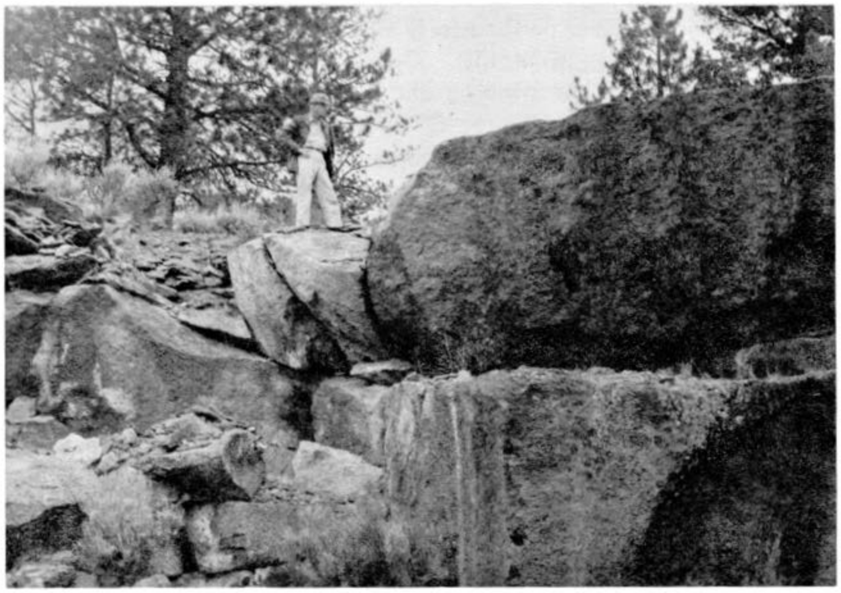


Figure 16. Outcrop of ash-flow tuff of the Qwt unit along Teepee Draw. The partly welded ash flow grades from dark brown near the base to reddish orange at the top. Newberry Volcano is believed to be the source.

This is probably the same ash flow reported by MacLeod and others (1975) to be 0.7 ± 0.7 m.y. old.

On the west flank of Newberry, near the surface, a thin layer of dark brown to black tuff breccia of probable ash-flow origin covers several square miles. Much of the matrix and most of the rock fragments are pumiceous to cindery with iridescent coatings. Gray to tan, rounded rhyolite fragments are common. Feldspar crystals are abundant in both groundmass and fragments. It is not known whether this deposit was erupted from within the caldera or from one of the numerous volcanic vents on the upper west flank of the volcano.

The ash-flow tuff units Qwt on both the County and Bend quadrangle geologic maps contain important mineral resources. Pumice in the vicinity of Bend and Tumalo has been mined from pits and marketed throughout the Pacific Northwest since the mid-1940's. The present production of nearly 500,000 cubic yards (382,000 m^3) annually has a value of over a million dollars. Building stone from the partially welded parts of the ash flow tuffs has been quarried for use locally since the early 1900's. Production of building stone is less steady and is only a fraction of that of the pumice industry; however, even though only a few hundred to a few thousand tons are quarried annually, the price averages much higher per ton than pumice. A more detailed discussion of both the pumice and building stone potential is contained in the Industrial Minerals section.

Pleistocene and Holocene Basalt Flows

Basalt flows (Qb)

Pleistocene basaltic lava flows of both pahoehoe and aa types are the most widespread and voluminous of the surface rocks in the County. They underlie much of the area on the east flanks of the Cascade Range, as well as the area surrounding Newberry Volcano, extending northward to the Crooked River north and east of Redmond.

The oldest of the Qb Pleistocene basalt flows are exposed west of the Deschutes River. These lavas came from vents on the flanks of the High Cascade volcanoes and occur as linear bodies as thick as 100 feet (30 m) that flowed over a slightly eroded northeasterly sloping surface. Chemical composition, texture, and structure of separate flows vary considerably. Generally the flows are dark gray to black and dense, but porphyritic. Some show flow banding and a platy jointing resulting from flowage as they cooled. Most are moderately vesicular. Like the QTb rim-capping lavas in the north part of the County, some of the Qb lavas are clearly channel fillings of former streams that flowed northeastward from the High Cascades. Where the contact can be seen, the underlying rocks are usually stream gravels that directly overlie the widespread Qwt ash-flow tuff deposits. With more detailed work, most individual flows might be traced to their source. Vents for the Qb flows are either lava cones and shields mapped as QTmv or cinder cones mapped as QTp.

The most conspicuous and widespread of the Pleistocene Qb flows are the relatively thin sheets of pahoehoe basalt associated with fissure eruptions on the flanks of Newberry Volcano. The flows occupy the large area bounded on the west by U. S. Highway 97, on the north by Redmond and the Crooked River, on the east by Horse Ridge and Powell Buttes, and on the south by the north flank of Newberry Volcano. Figures 17 and 18 are views of the hummocky topography of these pahoehoe flows. Fresh ropy surfaces, tumuli, and collapse depressions are typical of this lava terrain, locally called the "Badlands" or the "Lava Badlands." Newly broken surfaces show the basalt to be light to medium gray, medium grained, with characteristic diktytaxitic texture (open arrangement of the intergrown crystals of feldspar, pyroxene, and olivine). Sceva (1968) determined that in much of the area the lava flows extend from land surface to depths of 50 to 100 feet (15 to 30 m).

Within the "Badlands" field are individual lava tubes and extensive lava-tube systems through which the pahoehoe lava flows advanced and spread laterally. Greeley (1971) describes in detail most of the known lava tubes in the Bend area. An interesting lava-tube system not studied by Greeley is called the Redmond Caves, on the southeast edge of the city in sec. 21, T. 15 S., R. 13 E. These lava tubes distributed the Qb lavas northwesterly into a large dry canyon that trends northward along the west edge of Redmond (Redmond geologic map and Figures 19 and 20). The confined lava was then funneled northward to spread over a wide area west of Terrebonne and farther north beyond the boundary of Deschutes County.

Figure 17. Typical topography and vegetation along U.S. 97 both north and south of Bend, where "Badlands" lavas form an uneven surface thinly covered with wind-blown ash, cinders, and pumice.

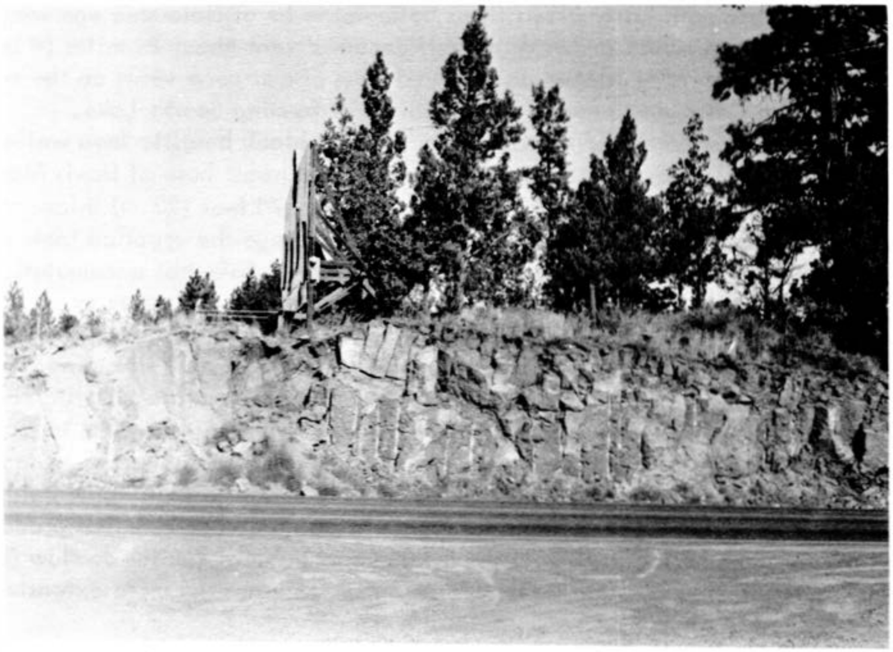


Figure 18. Roadcut north of Bend shows thinness of soil zone and structure of one of the low, rounded tumuli in lavas of the Qb unit and the typical joint pattern in the basalt. Most excavations for streets and utilities in Bend and Redmond encounter this lava.

The youngest of the three Qb "Badlands" lava flows covers a roughly circular area of about 30 square miles (80 km^2) north and east of Horse Ridge and were erupted from a slightly elevated fissure vent just north of Highway 20. Figure 21 shows the relatively small vent area with its distributary lava tubes.

Vents higher on the north and east flanks of Newberry Volcano erupted flows of a more viscous basalt, which is typically dark gray to black, dense, and porphyritic and has blocky hummocks on its surfaces. These flows now appear as thick tongue-shaped northeast-trending landforms extending into Millican Valley just east of Horse Ridge.

A distinctive porphyritic diktytaxitic basalt flow extends northward from the base of Pilot Butte, an interesting cinder-cone vent of Pleistocene age on the eastern edge of Bend. Future studies could easily delineate this and similar individual flows, which could help unravel the events in this spectacular local volcanic landscape.

Large quantities of vesicular basalt rubble have been removed from the surface of the Qb lava flows for use as building stone in walls, fireplaces, and other building construction. No estimates are available for the amount used or the annual value. The large area covered by the Qb lavas represents an apparent inexhaustible supply; however, only the top few feet of the flows are jointed so that they break into usable stone. The Qb lavas represent only marginal quality crushed rock because of this vesicularity, and the thinness of the individual flows and the lack of closely spaced jointing makes crushing difficult, so the supply from any one source is small.

Holocene basalt flows (Qhb)

Within the last 10,000 years, both aa and pahoehoe basalt flows have erupted at several places in the High Cascades and on and around Newberry Volcano. Ages for some of the flows have been determined by dating charcoal from trees that were inundated by the lavas. Lobes of spiny black aa lava extend eastward from the McKenzie Pass area into Deschutes County from Belknap Crater, Little Belknap, and from Yapoah Cone on the north flank of the North Sister. Taylor (1965, 1968) described these lava flows in detail and, from C-14 dating, determined that they range in age from 2,500 to 3,000 years. Farther south on the lower south slopes of South Sister, lava flows believed to be of Holocene age were erupted from LeConte Crater, from Cayuse Crater, and from a small unnamed vent about 2½ miles (4 km) south of Broken Top. Lava flows assumed to be of Holocene age erupted from cinder cone vents on the north side of Bachelor Butte and flowed westward to dam a broad drainage, forming Sparks Lake.

In the extreme southwest corner of the County a viscous, black basaltic lava welled up and spread outward from a series of small, closely spaced vents near the northwest base of Davis Mountain. This flow, which is about 3 miles (5 km) long, 1 mile (1.5 km) wide, and 70 feet (20 m) thick, dammed the channel of Odell Creek and formed Davis Lake (see Figure 22). How long ago the eruption took place is not known. The freshmess of the blocky lavas is deceiving, however, for Davis Lake has accumulations of diatomite as much as 4 feet (1+ m) thick that must have required at least a few thousand years to accumulate.

As reported by Peterson and Groh (1969), several episodes of Holocene volcanism are well recorded within and around Newberry Volcano. Of particular interest is a northwest-trending rift zone, traceable from within the caldera to and beyond Lava Butte, from which eight separate basaltic aa flows have been erupted (Figure 23). The flows vary in size from less than 1/2 square mile (1 km^2) in extent and a few feet (meters) thick to the largest and thickest of the flows at Lava Butte, covering 10 square miles (25 km^2) and ranging in thickness from 30 to 100 feet (10 - 30 m). Tree molds containing carbonized wood are present in most of the flows, and C-14 dating shows that the volcanic activity that produced the molds occurred in a relatively short period of time about 6,000 years ago. A similar aa flow (Surveyor Flow) on the south flank of Newberry also has tree molds and is the same age as the more extensive flows on the north flank.

A large basaltic pahoehoe lava flow of questionable Holocene age has been mapped in the area east of China Hat and East Butte. The flow, thickly covered with pumice from Holocene explosive eruptions from within Newberry Volcano, covers about 30 square miles (80 km^2). It flowed northwestward around the south and west base of Pine Mountain from an inconspicuous vent near Firestone Butte. The pumice cover on this flow supports a pine forest; however, the ropy surfaces, tumuli, and other initial flow surfaces are preserved and are especially conspicuous at its northern terminus (Figures 24 and 25).

Figure 19. Redmond Caves, in sec. 21, T. 15 S., R. 13 E., are in the collapsed part of a lava tube system that distributed lavas of the Qb unit into Dry Canyon extending northward through Redmond.

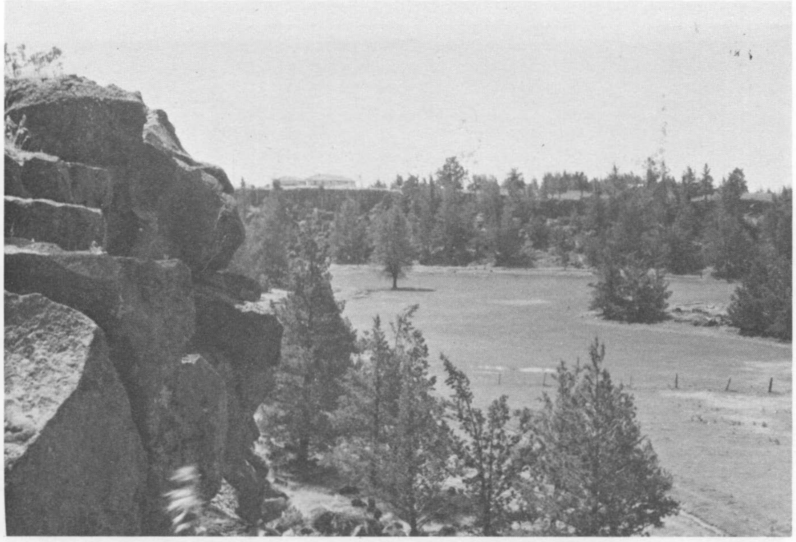


Figure 20. View across Dry Canyon at north edge of Redmond. Grass-covered floor is alluvium underlain by "Badlands" pahoehoe lava from lava tube shown in Fig. 19.

Figure 21. Collapse depression and partly filled lava tube near Horse Ridge north of U.S. 20 marks the vent for the latest "Badlands" lava eruptions. Highway cuts expose fresh, gray, diktytaxic olivine basalt.

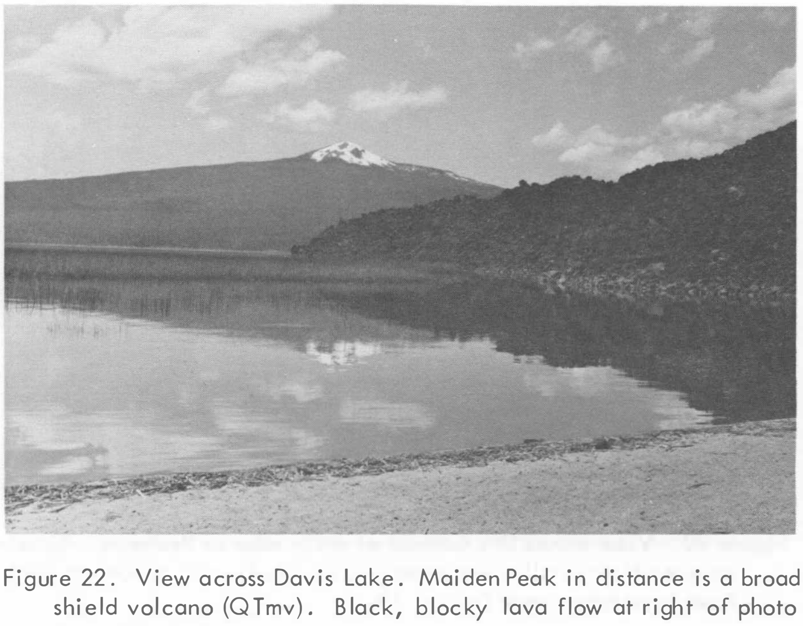


Figure 22. View across Davis Lake. Maiden Peak in distance is a broad shield volcano (QTmv). Black, blocky lava flow at right of photo impounds the lake.

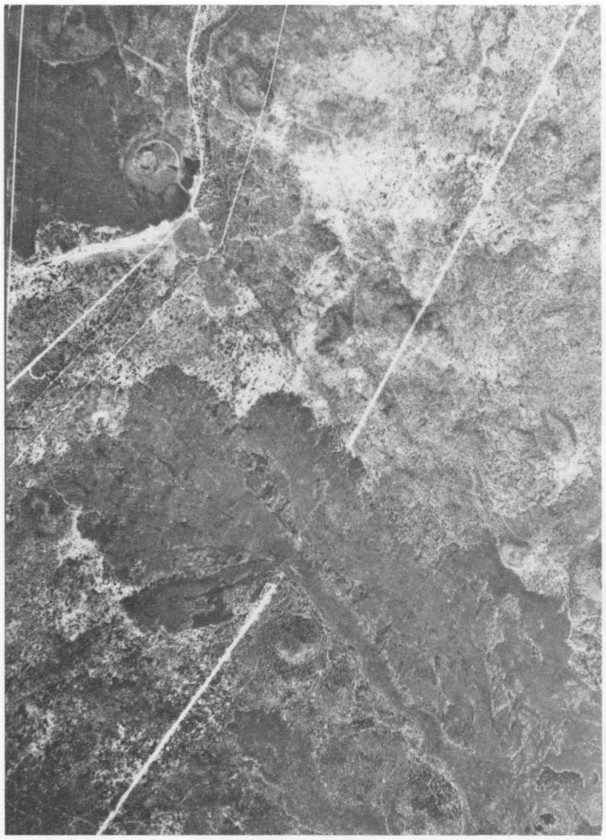


Figure 23. High-altitude aerial view of Lava Butte (upper left corner of photo) and one of the Qhb lava flows on the northwest rift zone. Mazama pumice masks older cones and flows. White diagonal line is the natural gas pipeline.

During the field checks for this report a very small Holocene volcanic vent and associated lava flow was discovered about halfway up the east flank of Sitkum Butte, which is a palagonite tuff cone (Figure 26). The vent area is a north-south fissure, about 1,000 feet (350 m) long, over which several small spatter cones have developed. Lava flowed eastward from this fissure and covered an area of less than 1/4 square mile (1 km^2).

Most of the Holocene basalt flows are of the aa or block type with extremely rubbly surfaces. Much of the surface rubble is scoriaceous to highly vesicular, with only minor economic potential for building stone and construction use.

Pleistocene and Holocene Silicic Domes and Flows

Pleistocene and Holocene dacite and rhyolite intrusive-extrusive rocks are restricted, with a few exceptions, to the Middle Sister-South Sister area in the Cascades and to the flanks and summit caldera of Newberry Volcano. These rocks represent two main episodes of silicic volcanism: Pleistocene, mapped as Qrd, and Holocene, mapped as Qhr.

Pleistocene silicic domes and flows (Qrd)

Dacite and rhyolite domes and flows mapped as Qrd in the Cascades have been glaciated and partly devitrified. The largest areas of such rocks are on the east flank of South Sister and in the area of Tam McArthur Rim near Broken Top. Two smaller but thicker dacite flows make up Devils Hill and Kaleetan Butte. To the east of the Cascades, Melvin Butte and Three Creek Butte are isolated dome-shaped masses of fragmental rhyolite resembling cinder cones. The rhyolite is light gray to white, finely crystalline, and slightly iron-stained from oxidation of iron-bearing minerals.

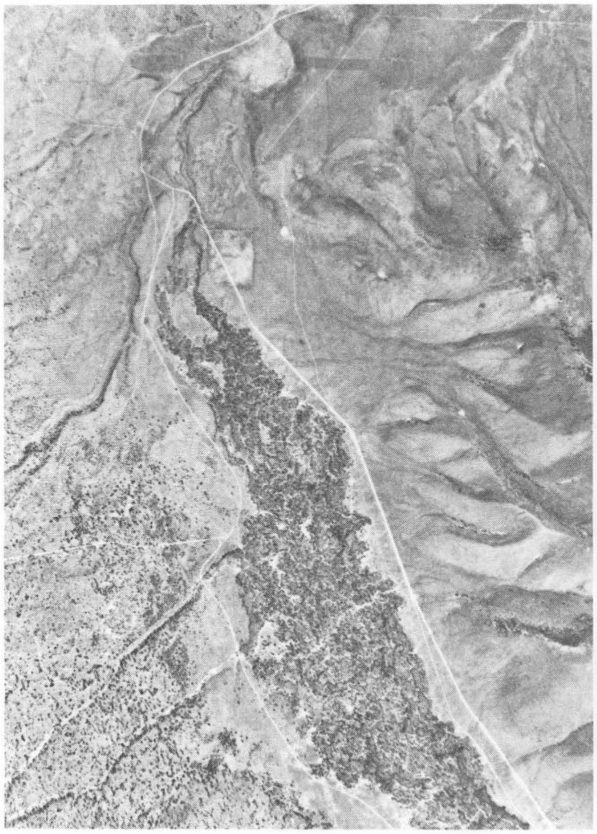
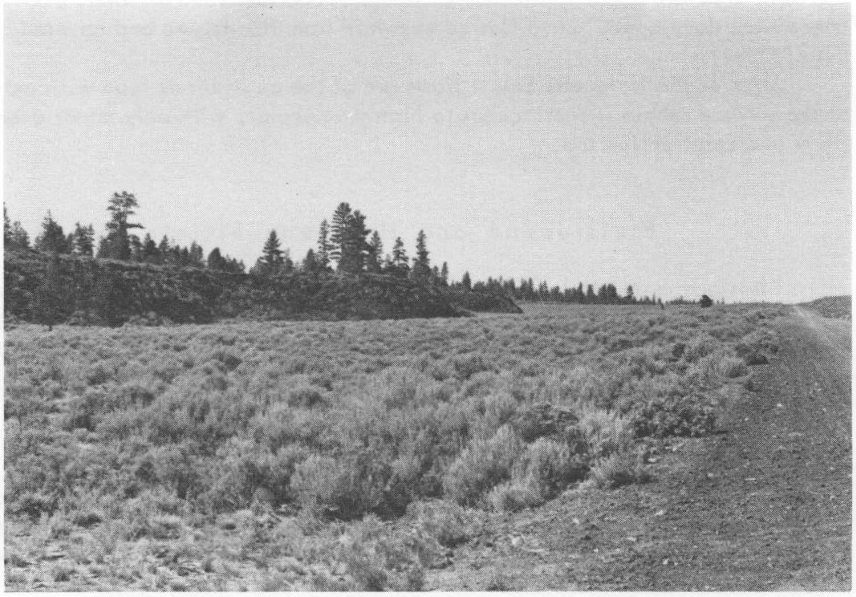


Figure 24. High-altitude aerial view of the Holocene pahoehoe lava that skirts the southwest side of Pine Mountain. The lava flowed down a shallow valley, spreading in toes and protuberances as it advanced.

Figure 25. View of margin of the above lava flow showing steep edges and protuberances.



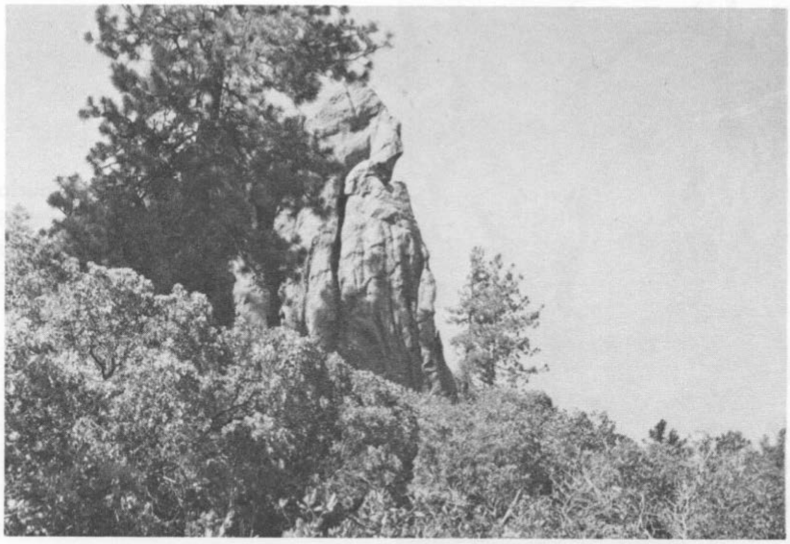


Figure 26. The erosional remnant of a palagonite tuff cone on Sitkum Butte resembles an Indian chief in silhouette. The name is assumed to be of Indian origin - was there a Chief Sitkum?

Bench Mark Butte, just north of Crone Prairie Reservoir, is a broad, dome-shaped mass of dense black andesite-dacite vitrophyre that built up over a centrally located vent. It covers almost 3 square miles (8 km^2), averages 200 feet (60 m) thick, and has concentric ridges and bulbous toes of large blocks that outline its initial structure.

Rhyolite-dacite domes at Newberry Volcano have been described in detail by Williams (1935), Higgins and Waters (1967), and Higgins (1973). The older group of silicic rocks (Qrd) are exposed in the caldera of Newberry Volcano on the lower northeast wall, at Paulino Peak, in parts of the south wall, and in two dome-shaped masses on the south shore of Paulino Lake.

Satellite domes and flows of light-gray flow-banded rhyolite, breccia, and black streaky obsidian occur at McKoy Butte on the northwest flank of Newberry Volcano and at Chino Hot and East Butte on the lower east flank.

Quartz Mountain, a slightly older dome complex of obsidian, lies southeast of Newberry on the south edge of the County. MocLeod, Walker, and McKee (1975) list K/Ar radiometric dates for some of the domes on the flanks: Quartz Mountain 1.11 ± .05 m.y.; East Butte 0.85 ± .05 m.y.; Chino Hot 0.78 ± 0.20 m.y.; and East McKoy Butte 0.58 ± 0.10 m.y.

Holocene silicic domes and flows (Qhr)

The Holocene rhyolite and dacite domes and flows (Qhr) occur on the south flank of South Sister and at Newberry Volcano. Beginning at an elevation of about 7,900 feet (2,600 m) and extending almost due south to Century Drive is a string of nine or ten spectacular dacite obsidian domes and flows (Figures 27, 28, and 29). As described by Williams (1944), "No doubt the extrusions occurred in rapid succession, possibly within a few days or weeks, and by analogy with fissure eruptions in other regions it is likely that activity began at the upper end of the chain and moved progressively downward." Minor eruptions of pumice preceded this latest upwelling of obsidian in the South Sister area.

The largest single obsidian dome and flow, covering about two square miles (5 km^2), occurs at Rock Mesa on the Cascade divide, partly in Lane County and partly in Deschutes County and within the Three Sisters Wilderness area. Rock Mesa has recently had national publicity because of litigation over the

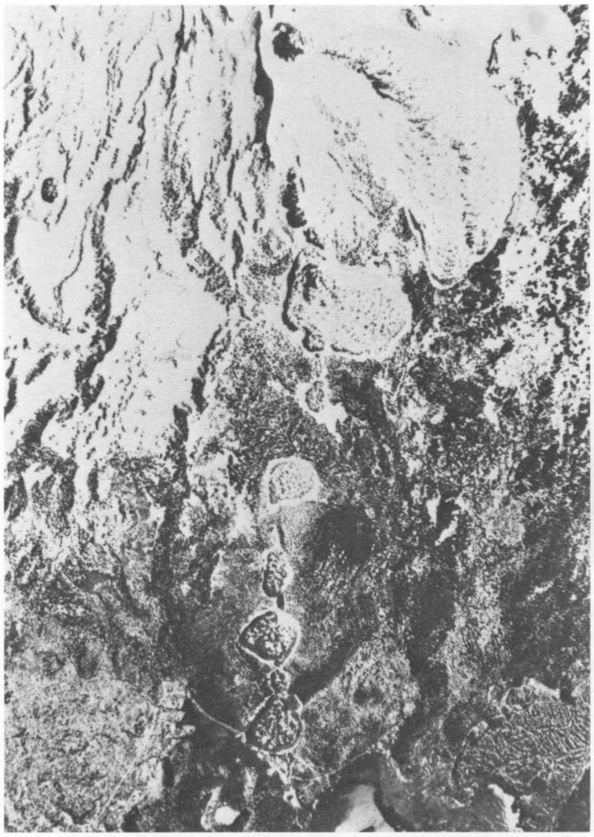


Figure 27. High-altitude aerial view of the chain of Holocene obsidian domes which were built over a fissure on the south flank of South Sister.

Figure 28. Two generations of glassy rhyolite-dacite domes. Upper left is glaciated Devils Hill. Uneroded domal surface to the right is the southernmost in the chain of obsidian domes.

Figure 29. Mid-winter view of Rock Mesa on the south flank of South Sister. Snow cover accentuates concentric ridges of spiny obsidian that welled up over a now-concealed vent. Broken Top is in left background. (Oreg. Hwy. Div. photo 6175)

validity of mining claims for block pumice that occurs with the obsidian. The age of Rock Mesa has recently been determined to be 2,300 ± 150 years before the present.

At Newberry Volcano, all of the Holocene silicic activity took place within the caldera, with the exception of one small rhyolite obsidian dome discovered on the southwest flank. At least five spectacular obsidian flows (Qhr) have been described in detail by many authors. Williams (1935), Higgins and Waters (1967, 1968) recognized that these flows were some of the youngest of Newberry's volcanic features. Charcoal from beneath the Big Obsidian Flow (Figure 30) has been determined from C-14 dating to 1,270 ± 60 years old. The ages of several other obsidian flows within the caldera have been determined by the thickness of their hydration rinds, a dating technique developed by Friedman (1968, 1971). The ages vary from 1,350 to 5,000 years B.P., confirming their Holocene origin (Peterson and Groh, 1969).

Block pumice has been selectively mined from the surface of the Newberry Volcano Holocene obsidian domes for years. The economic potential of block pumice within Newberry caldera and in the South Sisters area will have to be weighed against the scenic and recreational value of these areas.

Figure 30. Snow on Big Obsidian flow in Newberry caldera accentuates flow lines and pressure ridges that developed as the pasty magma spread outward from its vent close to the south rim of the caldera approximately 1,270 years ago.

Surficial Deposits

The unconsolidated surficial deposits fall into two general categories: l) the glacial and glaciofluvial deposits (Qgm), which includes lateral and terminal moraines, glacial drift, and outwash gravels; and 2) alluvium (Qal), comprising all the other stream-deposited gravel, sand, silt, the air-laid ash and pumice, slope wash deposits, alluvial fans, and sand dunes.

The surficial deposits provide most of the sand and gravel for Deschutes County and are an important industrial mineral resource. The sand and gravel chapter discusses their impact in more detail.

Glacial and glaciofluvial deposits (Qgm)

Taylor (1968) has recognized three episodes of glaciation in the High Cascades during Pleistocene time as follows:

> "The great extent and depth of glacial ice which lay upon the High Cascades of Oregon during the Pleistocene have not been stressed in geologic literature. In the central Cascades, three episodes of glaciation are easily recognized. The most recent episode is represented by fresh moraine and outwash between 7000 and 9000 feet elevation on high peaks. Radiocarbon ages of associated lavas and ash deposits indicate that these moraines were formed less than 2,500 years ago and should be referred to the Neoglacial 'Little Ice Age.' A minor glacial advance near the end of the last century slightly reworked some of the 'Little Ice Age' moraines.
>
> "The next oldest glacial stage ended 10,000 to 12,000 years ago and is here referred to the latest Wisconsin. During this time, a broad ice field accumulated in the High Cascades. It surrounded the major peaks, buried all but the highest summit ridges, and fed numerous glaciers, some of which were 19 miles long. Neither the ice field nor its satellite glaciers extended beyond the High Cascade platform; in the central Cascades few of these glaciers existed below 3600 feet elevation.
>
> "The oldest glacial events are collectively referred to as 'pre-latest Wisconsin.' They are recorded in deeply weathered and poorly preserved lateral and ground moraines, far removed from the Cascade Crest. These deposits lack the andesitic and rhyolitic rock types which are common in the summit peaks and in the latest Wisconsin moraines."

The glacial moraine material is a heterogeneous assemblage of volcanic rock types. It contains large blocks, boulders, and pebbles, ranging from angular to well rounded, in a finer sand and silt matrix.

A good example of "Little Ice Age" glaciation is shown by a well-preserved terminal and lateral moraine on the northeast flank of Bachelor Butte at the 7,800- to 8,000-foot (2375 - 2440 m) elevation (Figure 31). The moraines can be easily seen and interpreted from the Cascade Lakes Highway.

Moraines and outwash deposited by Wisconsin-age glaciers are more prominent in the northern part of the County, where they occur as a discontinuous belt on the east flanks of Mount Washington and on North and Middle Sister. Another broad belt of glacial detritus is present in the southwest part of the County, especially around Cultus Mountain and in the area between the The Twins, Maiden Peak, and Davis Mountain. Remnants of once larger lateral moraines are present in the upper parts of Trout, Squaw, and Tumalo Creeks. The broad flat north and west of Sister, Black Butte Swamp, and the flats surrounding Crane Prairie and Wickiup Reservoirs are probably underlain by glacially derived sediments, but for convenience they are mapped as alluvium (Qal).

Alluvium (Qal)

The largest alluviated area is the broad flat between Newberry Volcano and the High Cascades in the southern part of the County. This wide valley extends on both sides of the Little Deschutes and the Deschutes River from south of Lapine northward to Benham Falls. It also extends westward and northward to the headwaters of the Deschutes River and surrounds Crane Prairie and Wickiup Reservoirs. Although most of the detritus came from the High Cascades, large quantities of alluvium have been spread into the Lapine area from the west flank of Newberry Volcano.

Figure 31. Bachelor Butte from Century Drive. Lateral and terminal moraines deposited by a glacier extend halfway down the northeast flank.

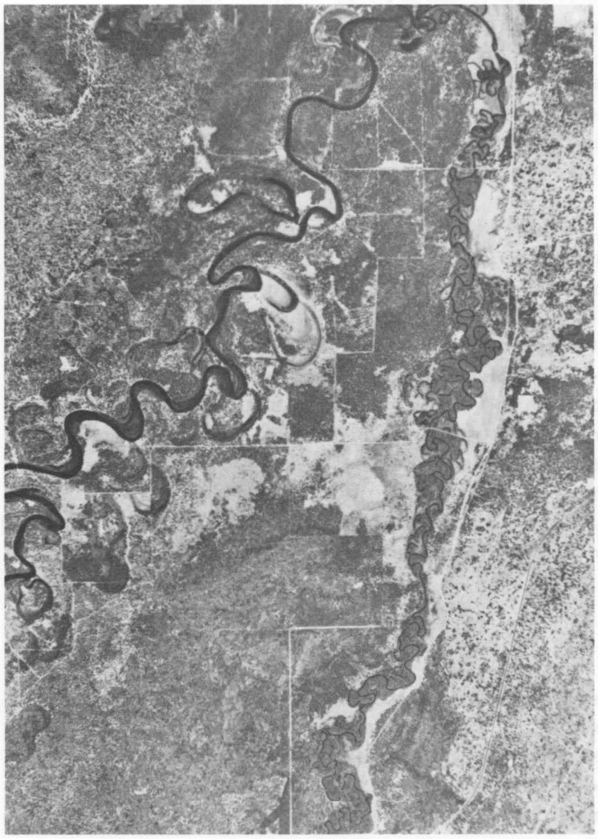


Figure 32. High altitude aerial view showing the meandering pattern of the Deschutes and Little Deschutes Rivers. Oxbow lakes and cutoff meanders indicate that the streams have reached base level in this area.

The extensive alluviation of this broad area has resulted from almost continuous constrictions of the Deschutes River by basaltic lava flows and glowing avalanche deposits. Lava flows from Newberry Volcano dammed the river countless times and forced it westward, while both basaltic lava flows and ash-flow tuffs from Cascade vents resisted this change and pushed the channel toward the east. The extreme meandering of the Deschutes and Little Deschutes River above Benham Falls indicates that base level has existed for a long time. Cut-off meanders, small oxbow lakes, and swampy ground are indicative of an old-age stream (Figure 32). The near-surface alluvium consists of a few feet of soil containing a mixture of pumice from Mount Mazama and reddish-black ash and cinders from the Holocene eruptions on Newberry's flanks; the underlying sediments are a crudely layered sand, silt, and gravel sequence that typically contains large percentages of a fine brownish pumice-cinder matrix with rounded pebbles of scoria and volcanic rocks. Well logs show a highly variable thickness of the alluvial materials ranging from a few tens of feet (meters) thick at Wickiup and Crane Prairie Reservoirs to 400 or as much as 500 feet (120-150 m) thick near the Little Deschutes River just north of Lapine. Much more detailed study will be needed to decipher the glacial, volcanic, and sedimentary history of this part of the Deschutes Basin. Chitwood (1974) has compiled a preliminary map showing the pattern of glacial outwash on Deschutes National Forest lands and included the area described above.

In the eastern part of the County, lake sediments and windblown sand have accumulated in Millican Valley from Horse Ridge eastward for about 15 miles (40 km). This broad, high-desert valley was the site of a sizeable lake for at least part of Pleistocene time. Layered sand, gravel, and silt exposed in roadcuts, borrow pits, and lake terraces along Highway 20 near Millican are as much as 50 feet (15 m) thick.

Dry River, a conspicuous meandering stream course cutting through the lake sediments,extends from the Brothers area to the west end of Millican Valley. Here, Dry River enters a narrow steep-walled canyon and within a distance of 3 miles (8 km) drops 500 feet (150 m) into the east part of the Deschutes Basin. At the viewpoint along Highway 20, near the Horse Ridge summit, the dry canyon is 300 feet (90 m) deep, and its steep walls reveal the many layers of lavas and pyroclastic materials of the Tb unit. It is apparent that the stream that carved this canyon drained the lake which once occupied Millican Valley. Whether the lake drained suddenly and catastrophically or gradually over a long period of time is not known.

A large gravel fan was built where the now-dry stream entered the Deschutes basin. Finer debris was distributed extensively to the north and west, but it is now mostly covered by the latest of the Badlands lava flows. In the vicinity of Alfalfa, where the sediments were not covered by basalt flows, the sand and gravel is at least 10 feet (3 m) thick and some has been mined for local road building. In the southwest part of the Millican Valley, large sand and gravel fans were derived from the somewhat eroded northeast flanks of Newberry Volcano. Tepee Draw and two unnamed dry stream canyons near Evans Well have distributed large quantities of sand and gravel into Millican Valley and to the area on the south side of Horse Ridge.

A less extensive high-desert valley extends along the southwest slopes of Hampton Buttes in the vicinity of Hampton. Shallow deposits of layered silt, sand, and gravel overlie and surround basaltic lava flows that floor the valley.

South of Pine Mountain, in the southeast part of T. 21 S., R. 15 E., one small area of airfall pumice, completely masking the underlying rocks, has been mapped as alluvium. The Kotsman Basin, at the southeast base of Pine Mountain is a small area of interior drainage that has been alluviated, and the surface there is also covered with pumiceous soil.

Minor amounts of alluvium are being deposited at the present time. Some glacial debris continues to be carried to lower elevations by meltwater from snow and ice fields, and occasionally a large quantity of debris is flushed down a choked stream canyon. Nolf (1966), reported such an event in October, 1966 when about 50 million gallons of water from a glacial lake on the east side of Broken Top Volcano was suddenly released into the drainage of Soda Creek.

The Deschutes River, Tumalo Creek, and Squaw Creek are continually reworking and slowly moving sand, silt, and gravel downstream, and the many lakes and reservoirs are receiving small amounts of fine-grained sediment. Minor amounts of wind-deposited sand is accumulating in dunes and ridges at the west end of Millican Valley.

No attempt has been made to map all the smaller patches of alluvium.

GEOLOGIC STRUCTURE

Because of the very limited extent of rocks older than Pliocene age in Deschutes County, the structure of these older units is obscure. The dips of the small outcrop areas of siliceous tuffs of the John Day Formation in the northeast part of the County at Coyote Butte and Smith Rocks indicate that a southwest plunging anticline passes beneath the essentially horizontal Deschutes Formation and younger lava flows.

Three major tectonic features are evident in Deschutes County. They are the Brothers fault zone, the High Cascades lineament, and Newberry Volcano. These three features roughly define a triangular area (Figure 33, sketch map) where Quaternary volcanism has been concentrated.

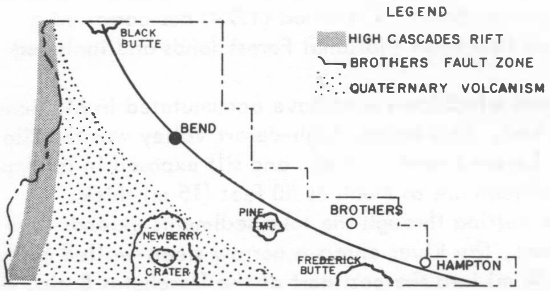


Figure 33. Sketch map of Deschutes County showing the three major tectonic features.

Brothers Fault Zone

The Brothers fault zone is a northwest-trending belt of closely spaced en echelon normal faults (Figure 34). It has been described by Higgins and Waters (1967), Walker and others (1967), and Walker (1969). Stewart, Walker, and Kleinhampl (1975) consider it to be part of the northwesterly portion of the "Oregon-Nevada lineament·" which extends from Mount Jefferson in Oregon southeastward into north-central Nevada. Walker (1969, p. 79) suggests that the "Normal faults of the zone and the many volcanic vents along the zone represent only the surface manifestations of deformation on a large deeply buried structure, the exact nature of which is not known. The pattern of normal faults within and near

Figure 34. The small community of Brothers, on U.S. Highway 20, is situated on the Brothers fault zone.

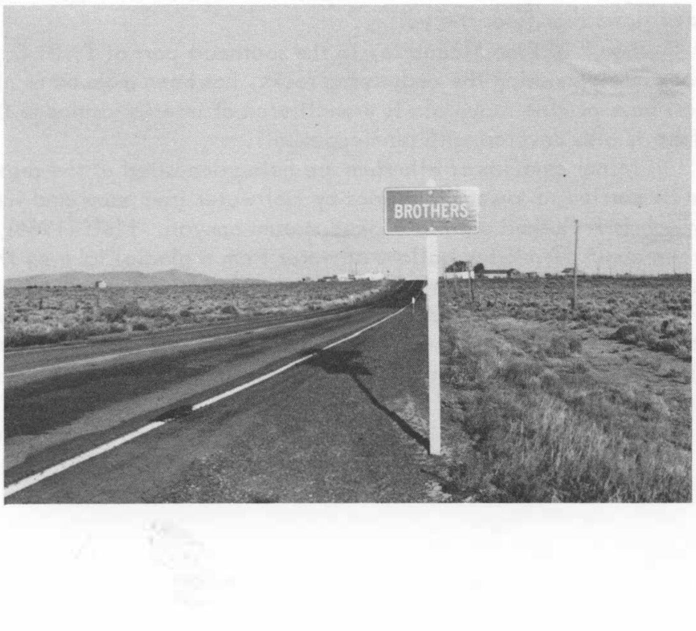


Figure 35. The recency of some of the faulting in eastern part of County is shown by this slickensided fault plane exposed in a rock quarry in sec. 22, T. 21 S., R. 20 E., near Hampton Butte.

Figure 36. Faulting has created vertical offsets in Pleistocene Qb "Badlands" lava flows. In Bend, between 3rd and 4th Streets, a large commercial building is on upthrown side of fault and smaller residence on down side.

the Brothers fault zone and the relation of many small monoclinal folds to the faults suggest, however, that the zone overlies a deeply buried fault with lateral displacement; the normal faults denote only adjustment of surface and near-surface volcanic and tuffaceous sedimentary rocks." (Figure 35.)

The northwest-trending faults of the Brothers fault zone have displaced all the rocks in the area except the latest Pleistocene "Badlands lavas." The latest displacements of the lava flows are relatively small, in most cases only ten to a few tens of feet (Figure 36). Some of the slightly older shield volcanoes and mafic vents, such as Bear Creek Buttes and Horse Ridge, show displacements on the faults of as much as a few hundred feet (100 m). Horse Ridge has been faulted into a horst and graben structure.

High Cascades Lineament

The structural weaknesses along the High Cascades lineament generally trend north-south and are marked by aligned cinder cones, explosion craters, and in some cases by large composite volcanoes. Visible faulting is only minor, but young volcanic activity has been concentrated on a grand scale.

The Bachelor Butte, Kwolh Butte, Sheridan Mountain chain is typical of the larger aligned vents. Another interesting north-south alignment is marked by four small explosion craters (maars) now occupied by South Twin Lake and North Twin Lake, with two unnamed craters between. The alignment continues northward into Shukash and Palanush Buttes which are small cinder cones. An older alignment, parallel to the High Cascades, but trending slightly northeast, is marked by Gilchrist Butte, Haner, Wright, Wampus, and Pringle Buttes. Gilchrist Butte, a steep-sided shield volcano with several periods of volcanism, has been faulted by a N. 15° E. normal fault that extends for about 10 miles northeastward to the north end of Pringle Butte. This is the only faulting in the High Cascades zone where vertical displacement is conspicuous.

Another distinctive zone of weakness is marked by the north-south string of Holocene obsidian domes on the southeast flank of South Sister. Many other examples can be easily seen on the geologic map.

Newberry Volcano

Almost as impressive as the previously described trends is the large shield of Newberry Volcano, which covers an area of about 600 square miles (1560 km^2). Newberry Volcano has a summit caldera (Figure 37), formed by subsidence on concentric faults as lavas from beneath the volcano were erupted from vents on the flanks. Higgins and Waters (1967, 1968) have described other minor faults within the summit caldera. The concentric fractures are marked by cinder and spatter cones, and the 150 or more cinder cones and small vents on the flanks of Newberry exhibit a general N. 25° W. trend, with concentrations on the southeast and northwest flanks. Most are shown on the geologic map. The strongest and latest structural trend begins within the caldera at the "Fissure" on the north wall of East Lake and extends northwestward for about 15 miles (24 km) to just north of Lava Butte (Figure 38).

Newberry Volcano lies about midway between the High Cascades and the Brothers fault zone. Although Higgins and Waters (1967) considered the Newberry shield to be located on the Brothers fault zone, more recent studies show that the fault zone passes to the northeast. The divergent rock types erupted from Newberry Volcano suggest an association with High Cascade volcanism. More detailed work will be necessary, however, to show whether the volcano is directly associated with either the Brothers fault zone or the High Cascades.

Most certainly these large-scale geologic features have plate-tectonic implications. Beaulieu (1972b) has reviewed the tectonic history of Oregon, using the concepts of plate tectonics as they are presently known. It is definitely known that in middle Tertiary time a radical change in tectonic behavior occurred. Prior compressional forces (plate subduction) with accompanying andesitic volcanism and thrust faulting were replaced by tensional forces with flood basalts and block faulting. The reason for the concentration of late Tertiary and Holocene volcanism in the Three Sisters and Newberry Volcano area is not yet well understood and, as Beaulieu suggests, "A plate tectonic model consistent with all the data is yet to be formulated."

Figure 37. Aerial view across Newberry caldera. Former shield volcano collapsed along concentric fractures, marked by south rim in this photo.

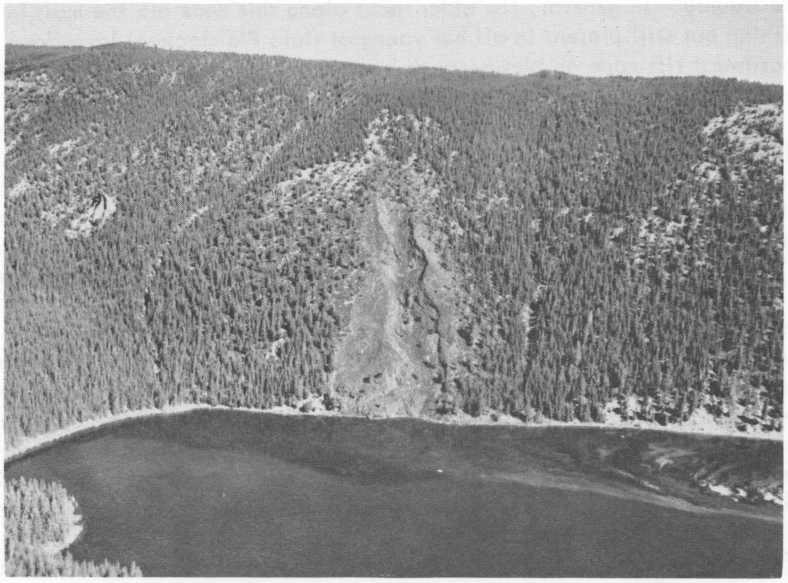


Figure 38. East Lake and north rim showing the "fissure," a fracture marking the beginning of the northwest rift zone which extends to or beyond Lava Butte.

GEOTHERMAL RESOURCES

Recent interest in Oregon for geothermal resources is high and our studies show a favorable geologic environment for parts of Deschutes County. The potential for the future development of this type of earth energy appears to be considerable.

Known geothermal resources of the world occur mainly in regions of recent volcanism and tectonism. The productive steam fields of The Geysers in California, Lardarello in Italy, and Matsukawa in Japan, and the very hot water reservoirs such as those of New Zealand, Iceland, Cerro Prieto in Mexico, and the Imperial Valley area of California are known to be associated with volcanism, tectonism, or both. Most lower temperature geothermal resources also have this association.

Natural steam and hot waters with temperatures above 392°F (200°C) can be used to generate electric power. Waters of lower temperature may be useful to generate electric power through the application of a heat exchanger and high-vapor pressure working fluid, but the main uses lie in the field of multi-purpose heat. Major uses for the lower temperature waters include residential and building space heating, greenhouse heating, agricultural product drying, and food process heating and drying. Iceland, New Zealand, Hungary, and Klamath Falls, Oregon are places well known for the multi-purpose application of geothermal energy.

Intense volcanic and tectonic activity has been the geologic history of Deschutes County. Volcanic activity in the Quaternary ($2\frac{1}{2}$ million years to the present time) has been especially pronounced within the County. This is shown in the building of the great Newberry Volcano, a shield complex, and the continuation of volcanic activity of this feature essentially to the present time. It is also evident in the Quaternary volcanism of the High Cascades, particularly the Three Sisters-Broken Top area, the Mount Bachelor-Sheridan Mountain chain, and the Kiwa Butte area.

Tectonic activity within Deschutes County is evident from the presence of the Brothers fault zone passing through the County. In general, the older rocks along this zone are the most intensely faulted, with faulting dimishing but still present in all but youngest (late Pleistocene) lava flows of the "Badlands." Faults along the northwest rift zone on Newberry Volcano (Peterson and Groh, 1965) seem to be the most recently active.

In the light of this strong volcanism and tectonism within the County it is surprising that only two surface thermal displays are known. Both exist within Newberry Caldera (Newberry Crater). One series of hot springs is present along the northeast shore of Paulina Lake and extends into the lake. Maximum measured temperature is 135°F (57.3°C), and gas, mainly of CO_2, is emitted. The other display is located along the south shore of East Lake. It also extends into the lake and has a maximum measured temperature of 150°F (65.6°C), and gas, including hydrogen sulfide, is emitted. Temperatures of these springs are no doubt affected by dilution with cool lake waters.

Subsurface-temperature data from wells in the County are scarce; but available information indicates a temperature gradient below normal. Two holes southwest of Bend were measured to a depth of about 400 feet (122 meters). The gradients were essentially isothermal with bottom-hole temperatures of 9.5°C (49°F). The below-normal geothermal gradient and probable lower-than-normal terrestrial heat flow may be the result of ground-water migration,since the regional heat flow pattern for this part of Oregon is expected to be in the normal to above-normal range. Sceva (1968) suggests a northward migration of ground water in the Deschutes River basin with cooler waters in the Bend area and increasing temperatures toward the north.

Walker (1974) and MacLeod and others (1975) have reported on the progressive decrease in the age of silicic volcanic eruptions from east to west along the Brothers fault zone in Oregon. Silicic volcanism near Glass Buttes, just south of the eastern end of Deschutes County, has an age of about 5 million years. Westward are scattered younger silicic eruptions, and in Newberry Caldera the youngest silicic rock dated so far is about 1,300 years (Peterson and Groh, 1969). Still farther to the west, young silicic eruptions in the South Sister-Broken Top area are only a few thousand years in age. MacLeod and others (1975), reporting on the significance of geothermal potential in southeast Oregon, state: "Most electric-power-producing geothermal fields inthe world occur in or proximal to areas of young silicic volcanic rocks.

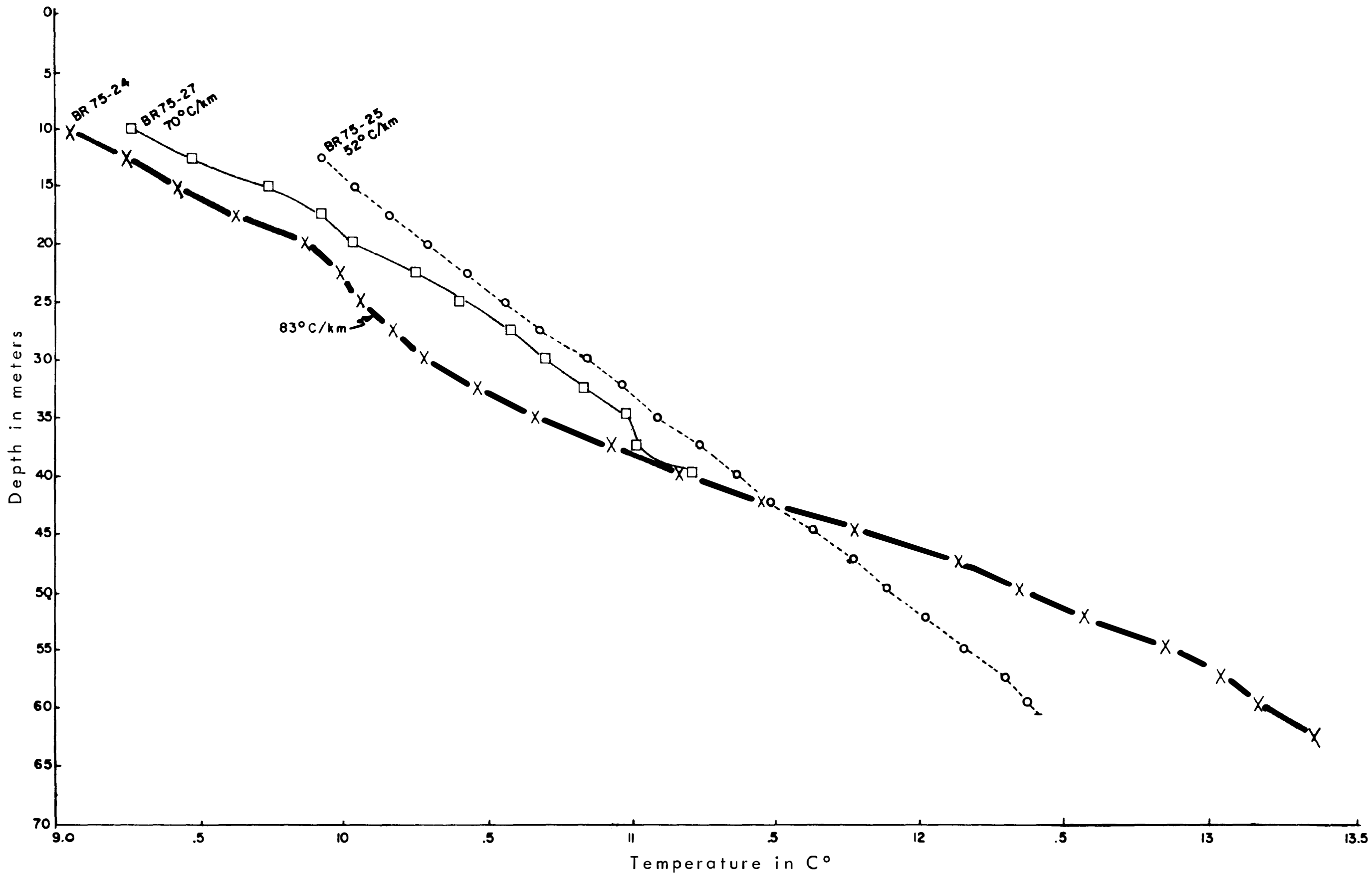


Figure 39. Diagram showing geothermal gradients for three wells, BR75-24, BR75-27, and BR75-25, drilled on a traverse across the Brothers fault zone between Hampton Butte and Frederick Butte.

On the basis of the well-defined age progression of rhyolitic domes in Southeastern Oregon, silicic bodies sufficiently young to be heat sources for geothermal systems are likely only in the vicinity of Newberry Volcano at the west end of the northern belt of domes."

Insufficient data about geothermal gradients, heat-flow, and lack of surface thermal displays does not necessarily preclude the possibility of a large geothermal potential for the County. Prospective areas with good potential include the Brothers fault zone, Newberry Volcano, and the High Cascade Range.

The Brothers fault zone and associated young silicic volcanism, as Walker (1974) says, deserve further study because of their poorly defined potential for geothermal energy. The Oregon Department of Geology is currently studying the Brothers fault zone to determine geothermal gradients across its strike. One traverse in Deschutes County, where 200-foot (60-meter) holes have been drilled for temperature measurements extends from Hampton Buttes to the area just south of Frederick Butte. Preliminary measurements (Bowen and others, 1976) show a slightly higher than normal gradient across the Brothers fault zone in the eastern part of Deschutes County (Figure 39). A more refined interpretation of the area heat flow will be made when more gradient measurements have been taken and when rock heat conductivities are determined. The Department's project includes a series of holes to be drilled for temperature measurement farther west, extending from Bear Creek Buttes to Quartz Mountain and at additional sites around Newberry Volcano.

Private companies are already showing interest in the Glass Butte area. A large number of applications for Federal geothermal leases have been filed. Environmental and other problems should be minimal for this relatively uninhabited prospective area.

As MacLeod and others (1975) suggest, Newberry Volcano and its caldera is a prime prospect because of the indications of a large probable heat source at a shallow depth within the crust. This aspect is apparently the reason that several major oil companies, other corporations, and numerous individuals have applied for Federal geothermal leases. Most of the more than 300,000 acres of Federal geothermal leases applied for in the County are on Newberry Volcano or in its caldera. The geological uniqueness, developed recreational facilities, and scenic aspects of the caldera seem to preclude any geothermal development within the caldera for the foreseeable future. A 1975 Oregon legislative resolution (H.J.R. 31) directed the State Energy Facility Siting Council to forbid thermal power plants in a 39,000-acre area which includes the Newberry caldera and the Lava Cast Forest geologic area. Subsequently, on November 12, 1975, the Energy Facility Siting Council took action to forbid thermal power plants in the designated 39,000 acres but to allow geothermal exploration outside the approximately 11,000 acres of the caldera and the 6,270-acre Lava Cast Forest geologic area.

The flanks of Newberry Volcano, although less favorable, may offer prospects for geothermal development with minimal environmental effects.

At the present time, geothermal prospects for the High Cascade range must be considered as speculative. Geologically the volcanicity of the area suggests large sources of heat brought to shallow levels of the crust; however, a great deal of preliminary exploration will be required to assess the geothermal resource potential. Here again, exploration and development of geothermal resources must be compatible with the environmental aspects.

NON-METALLIC MINERALS

Significance of Deschutes County Resources

The known mineral resources of Deschutes County are the non-metallic types called "industrial minerals." They include pumice, scoria, cinders, and building stone (products of volcanic activity) and diatomite, clay, and sand and gravel (deposits in lakes or river basins).

These materials represent an important asset to the economy of Deschutes County. Besides being available for local needs, they can satisfy export demand; fairly large quantities of pumice, scoria, and cinders and some building stone are shipped to other parts of the Pacific Northwest.

The industrial minerals are in adequate supply for the present time in Deschutes County; but certain mineral commodities, particularly sand and gravel, essential ingredients for concrete and economic only if near the place of use, could be zoned out of existence by expansion of urban developments across the surfaces of the deposits.

A review of mineral production statistics by the U. S. Bureau of Mines (Figure 40) shows that from 1950 to 1961 diatomite production from the Terrebonne deposit was the leading mineral industry activity in the County. Closure of the Terrebonne mine in 1961 is reflected by a sharp drop in the total mineral production for 1961. Since 1961, pumice (including scoria and cinders), sand and gravel, and stone, in that order of value, have been the significant mineral commodities produced in the County. The U. S. Bureau of Mines' dollar values are for raw products and in most cases represent only a fraction of the market value of the products.

The industrial mineral commodities are described below in alphabetical order, and the location of the individual mineral deposits and occurrences is shown on the Mineral Location Map and listed in the Appendix.

Building Stone

The surface and near-surface volcanic rocks in Deschutes County provide an almost unlimited supply of material suitable for use as rubble or rough construction stone. One large source is the vesicular basalt of the Pleistocene lava flows ("Badlands" lava), shown as Qb on the geologic map, which form the extensive plain from Bend to Redmond. The basalt has a characteristic jointing parallel to the surface that allows the near-surface part of the flows to break into relatively uniform rectangular blocks of varying thickness. The highly vesicular nature of the top part of the flows also presents a pleasing appearance when used in walls, facing for walls, fireplaces, monuments, or other construction uses (Figures 41 and 42).

Blocks of ash-flow tuff, mainly from the area west and south of Bend and near Tumalo, have been quarried, shaped, and used for building construction since the early 1900's (Figure 43). The material is still being used locally to make attractive walls and buildings (Figure 44), and small tonnages are marketed in the Willamette Valley and Portland areas.

Evidence of quarrying on a small scale can be seen at many places. The near-surface occurrences, ease of quarrying, and short haul make it possible for individual operators or small companies to produce stone with a minimum of capital investment when a market exists (Figure 45).

Clays

Characteristics and uses

Clay is technically defined as "a loose, earthy, extremely fine-grained, natural sediment or soft rock composed primarily of clay-size or colloidal particles, and characterized by high plasticity, and by containing a considerable amount of clay minerals (hydrous aluminum silicate) derived from feldspathic

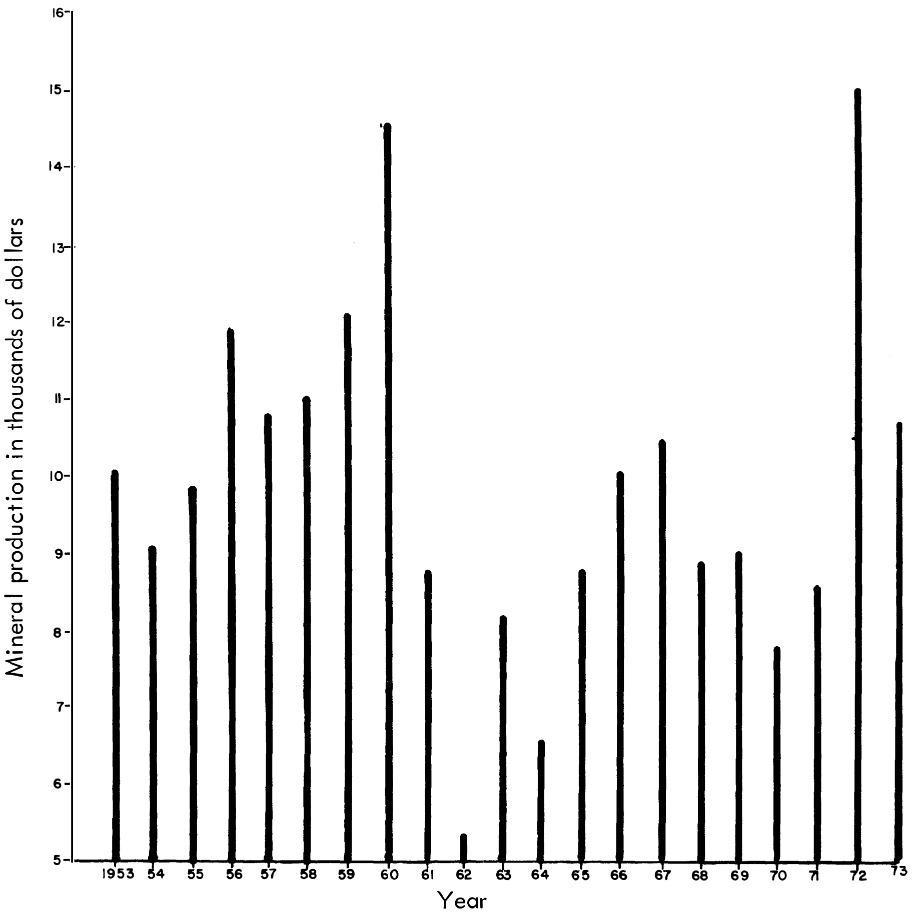


Figure 40. Deschutes County mineral production as reported by the U.S. Bureau of Mines. The high-value commodity up to 1962 was diatomite from the Terrebonne deposit. The low in 1962 marks the end of production at Terrebonne. From 1962 to the present, pumice (including cinders and scoria), sand and gravel, and crushed stone have been the significant commodities produced. The steep rise in production values of the early 1970's reflects the rapid population growth of the County.

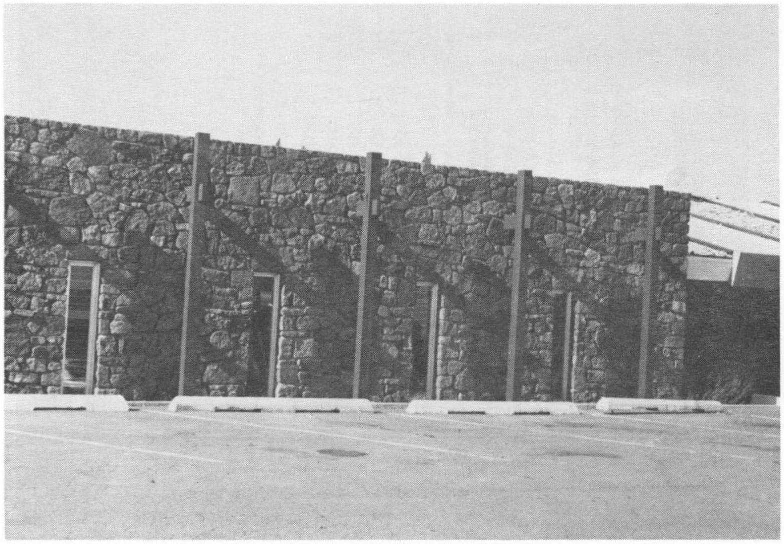
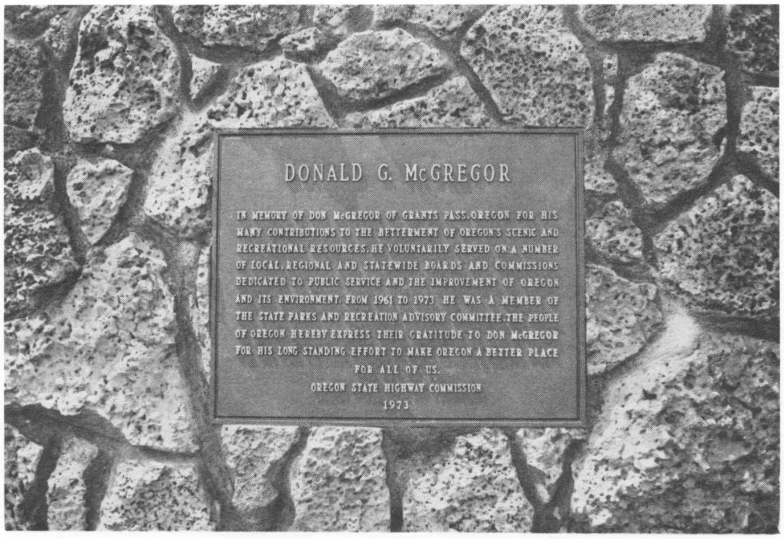


Figure 41. Vesicular basalt from the Pleistocene Ob lava was used to build this handsome rubble stone wall in a restaurant in Bend.



DONALD G. McGREGOR

IN MEMORY OF DON McGREGOR OF GRANTS PASS, OREGON FOR HIS
MANY CONTRIBUTIONS TO THE BETTERMENT OF OREGON'S SCENIC AND
RECREATIONAL RESOURCES. HE VOLUNTARILY SERVED ON A NUMBER
OF LOCAL, REGIONAL AND STATEWIDE BOARDS AND COMMISSIONS
DEDICATED TO PUBLIC SERVICE AND THE IMPROVEMENT OF OREGON
AND ITS ENVIRONMENT. FROM 1961 TO 1973 HE WAS A MEMBER OF
THE STATE PARKS AND RECREATION ADVISORY COMMITTEE. THE PEOPLE
OF OREGON HEREBY EXPRESS THEIR GRATITUDE TO DON McGREGOR
FOR HIS LONG STANDING EFFORT TO MAKE OREGON A BETTER PLACE
FOR ALL OF US.

OREGON STATE HIGHWAY COMMISSION
1973

Figure 42. Rubble stone from Qb lava flow was used to face the Don McGregor memorial at Lapine Recreation Area on the Deschutes River.

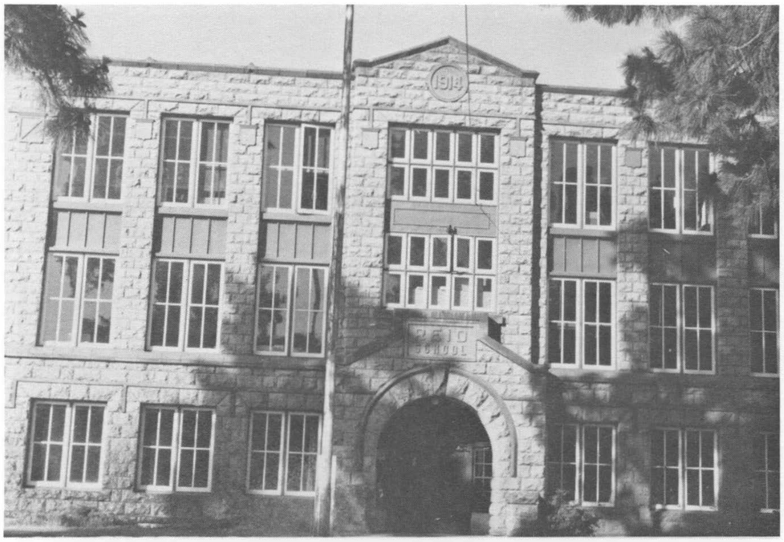


Figure 43. Rough blocks of Tumalo ash-flow tuff were quarried and brought to the site where they were individually shaped and used to build the Reid School in Bend.

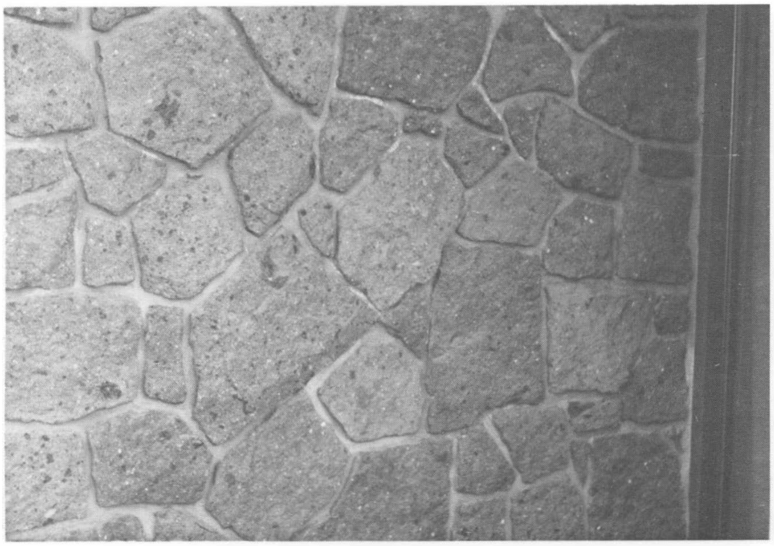


Figure 44. The welded portion of the black ash-flow tuff readily splits into roughly rectangular slabs of rubble stone. Here it has been used as wall veneer for a bank in Bend.

rocks by weathering (primarily decomposition) or by precipitation, and subordinate amounts of finely divided quartz, decomposed feldspar, carbonates, ferruginous matter, and other impurities: it forms a pasty, plastic moldable, impermeable muddy mass when finely ground and mixed with water, retaining its shape on drying, and becoming firm, rocklike, and permanently hard upon heating or firing."

The three groups of clay minerals, kaolin, montmorillonite, and illite, are all complex hydrous aluminum silicates with variable physical properties. Most are dense, flaky, fine-grained particles with the ability to absorb substantial amounts of water or other liquids. Clay minerals most commonly originate from either hydrothermal alteration or from chemical weathering of primary silicate minerals such as feldspar, pyroxenes, and amphiboles.

Most clay deposits contain mixtures of clay minerals, and for uses such as expanded aggregates, cement additives, or brick and tile they can be used untreated after crushing. For more specialized uses, such as making pottery, fillers, drilling mud, and binders, the clay must be ground, sized, and dried. Specialty clays like the kaolins, fire clays, and fuller's earth require more sophisticated processing.

Bentonite is a clay material composed of extremely fine crystalline montmorillonite and colloidal silica. Bentonite can absorb large quantities of water, increasing its volume to about eight times its original size. Its main use is to thicken drilling muds, but it can be used also for lining irrigation canals and ponds to prevent leakage.

Clay deposits in Deschutes County

Two occurrences of impure clay (Nos. 63 and 10) are shown on the Mineral Location Map.

No. 63 is the D. B. Anderson (Van Meter) clay pit, just west of Bend. It was the source of material used in making bricks for many of the buildings in Bend during the early 1900's (Figure 46). The deposit occurs on the downthrown side of a fault in an area underlain by ash-flow tuffs and small basaltic cinder cones. The finer ash from the tuffs accumulated along with cinders in a shallow undrained depression probably created by the fault. The material has been partially weathered to a mixture of clay minerals and clastic particles of pumice and cinders. For making brick, the coarser cinders and pumice were screened. It is reported that an updraft kiln built in about 1900 was fired with slab wood and had a capacity of 32,000 bricks a day. Apparently bricks were produced intermittently until about 1940. Until recently, pit-run material was sold in the Bend area for use as common fill.

No. 10 is the Edgar clay deposit in Sage Flat, about 5 miles north of Sisters. It appears to cover only a few acres and to be less than 10 feet thick. The clay is tan to brown and contains some carbonaceous material. It probably resulted from weathering of fine ash, cinders, pumice, and wind-blown materials confined in a small undrained basin created either by faulting or by a lava flow dam that blocked drainage in the upper part of Stevens Canyon. The heterogeneous fine-grained rock particles are not completely altered to clay. The material is a mixture of clay minerals including bentonite and could possibly have some use as a sealer of water storage ponds or irrigation ditches.

Diatomite

Characteristics and uses

Diatomite, or diatomaceous earth, is a friable, lightweight, light-colored, sedimentary material composed mainly of the microscopic siliceous skeletons of aquatic plants (algae) called diatoms. These plants are abundant in shallow marine or lacustrine waters where temperature, light, nutrients, and dissolved silica are favorable for their growth. The shells or frustules are composed of hydrous silica similar to opal, and each species has a characteristic shape, size, and ornamentation. Thousands of living and fossil species have been identified and described in the literature.

Pure diatomite is white, but inorganic sediment or carbonaceous impurities are usually present, imparting gray to tan colors to massive deposits. Because of the porous nature of the diatom shells (some contain 75 to 80 percent void volume), dry in-place materials are lightweight and range from 25 to 35 pounds per cubic foot. After processing, the dry powders range from 5 to 16 pounds per cubic foot. Most deposits consist of a variety of diatom species. The shape and size of the shells as well as shell fragmentation affect

Figure 54. Pallets of black ash-flow tuff rubble stone ready for transport to a Portland market. Stone from this quarry was used for the building shown in Fig. 44.

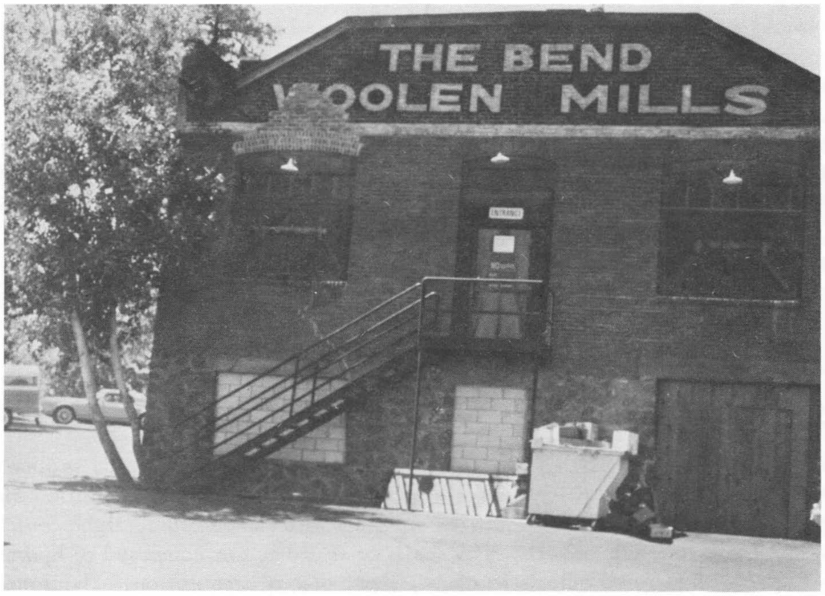


Figure 46. Locally made bricks from the Van Meter clay pit were used in many early buildings in Bend. This building, dating from the 1920's, now houses a tavern and restaurant.

the properties of the diatomite. Diatom shells are inert to most acids but will dissolve in strong alkalies.

Diatomite has a great variety of industrial uses as filters, fillers, insulating materials, absorbents and fluid carriers, aggregate and pozzolan for light-weight cement, abrasives, and ceramic products. Each use requires diatomite of specified purity, particle size, particle shape, and sorting. Since diatomite is a bulk product, a commercial deposit must be relatively pure, easily mined, and economical to process and transport to markets.

Living diatoms flourish in clear, cool, relatively shallow bodies of water with a high dissolved silica content that is regularly replenished. These conditions are most often found in areas of widespread volcanic activity where drainages have been disrupted to form lakes and the volcanic rock products easily contribute silica to ground waters.

Diatomite in Deschutes County

During the past several million years, conditions in Deschutes County have been favorable for the growth and accumulation of diatoms. A particularly noteworthy deposit of Pliocene-Pleistocene age occurs near Terrebonne. Thin beds of diatomite formed in temporary lakes dammed by lava flows across the upper Deschutes drainage. Diatomite is accumulating today in appreciable amounts in Davis Lake and in other lakes east of the crest of the Cascades.

Terrebonne deposit: Diatomite was an important commodity in the Deschutes County mineral industry from the early 1920's until 1961. Diatomite was discovered at Lower Bridge about 6 miles west of Terrebonne, probably by early settlers in the area. Subsequent exploration showed diatomite of good quality as much as 38 feet thick covering several hundred acres. Some diatomite is reported to have been mined and shipped before 1920; however, large-scale production did not begin until 1936. The Great Lakes Carbon Company acquired the property in 1944 and operated it until 1961, when the filter-grade diatomite was mined out. Total production must have been several million tons. The Terrebonne diatomite deposit has been described by Stearns (1931) and Moore (1937). Dyrsmid (1954) described the deposit, processing plant, warehouse, and shipping facilities.

The diatomite occurs within the upper part of the Deschutes Formation. It is underlain by a reddish-tan ash-flow tuff and overlain by a fairly thick layer of sand and gravel and also by the thin Pleistocene Badlands lava flows.

The immediate area around Lower Bridge has not been systematically prospected for similar deposits of diatomite; however, Stensland (1970, Revised 1974) has mapped outcrops of diatomite in sections 13 and 24 several miles east of the Terrebonne deposit. Possibly other tabular-shaped bodies of diatomite are covered by the thin Pleistocene lava flows in this local area.

Davis Lake diatomite: Moore (1937) reported an occurrence of diatomite of recent origin in and around Davis Lake. The relatively impure diatomite has accumulated to a thickness of 3½ feet in a lake that formed when Odell Creek was dammed by a lava flow west of Davis Mountain (Figure 22). Layered pumice beneath the diatomite may have been erupted by Mount Mazama. If so, it indicates how rapidly diatomite can accumulate if conditions for diatom growth are favorable. The associated ash and pumice and the thinness of the deposit make this occurrence of academic interest only.

Gemstones

Brightly colored agate, jasper, and fossil wood are present in minor amounts in Deschutes County. Although they are not technically industrial minerals and are of only minor economic importance, they furnish enjoyment and recreation for the many hobbyists who look for them. The gravelly layered sediments along the northeastern border of the County, unit Tst on the geologic map, contain some agate and jasper derived from the weathering and erosion of the Clarno and John Day Formations. Similar materials have also been brought into Millican Valley by streams entering from the northeast, and agate and jasper can be found in the gravels adjacent to U. S. Highway 20 from Millican to Brothers.

Pumice and Volcanic Cinders

As industrial mineral products, pumice, pumicite, and cinders are generally grouped together. These materials are the result of explosive volcanic eruptions, and the volcanic environment of Deschutes County has provided sizeable good-quality deposits. A thick blanket type deposit of lump pumice underlies at least 20 square miles southwest, west, and northwest of Bend; and block pumice is present as a frothy surface layer associated with obsidian flows both at Newberry Volcano and at Rock Mesa. Cinder-scoria cones and mounds are abundant throughout the County and represent an inexhaustible supply of good-quality material. Pumice, pumicite, scoria, and cinders have produced the greatest dollar value of any mineral commodity in Deschutes County since 1961, when the Terrebonne diatomite mine ceased operation.

Pumice and pumicite

Origin: Pumice is a light-colored, cellular, almost frothy rock made up of glass-walled bubble casts resulting from the violent expansion of gases in a viscous rhyolite or dacite magma. It may occur as coherent, massive blocks composed of highly vesicular glassy lava in either a flow or vent filling or it may be highly fragmented by violent eruption. When the fragments are less than 4 mm in diameter the product is called pumicite, even though it has the same origin, chemical composition, and cellular structure as pumice. Pumice is usually concentrated relatively close to the vent from which it was erupted, while pumicite may be carried by winds for great distances before settling as an accumulation of fine-grained ash.

Uses: The properties that make pumice and pumicite useful in industrial applications include light weight, good heat and sound insulation, and excellent abrasive capability. The main uses for pumice continue to be as a lightweight aggregate for building blocks, lightweight structural concrete, plaster aggregate, and as a soil conditioner. Other uses include polishing glass, metal, leather, wood, and stone. Some scouring powders and soaps contain pumicite, and minor amounts are used as fillers, absorbents, carriers for insecticide, catalyst carrier, and filters. Pumicite is also used in sizeable quantities as a pozzolanic additive in monolithic concrete: it increases the workability, strength, and durability of the concrete and reduces the heat of hydration.

Block pumice is merely a size designation, being the lump or chunk-size pumice. It ranges from 2 inches or more in one dimension to blocks over 5 feet in diameter. The smaller pieces have a variety of uses. They make excellent abrasive blocks for cleaning of restaurant grills, removing callouses, dressing grinding wheels, and polishing belts; pumice blocks are also used for straining vinegar. Larger blocks of rough pumice have a market in landscape architecture: their light weight permits easy transportation and handling.

Pumice and cinder production

Lump pumice, mainly for use as a concrete aggregate in the manufacture of building blocks, has been produced in the Bend-Tumalo area in large quantities since about 1940. Production has generally increased, with an estimated 380,000 cubic yards mined, processed, and sold in 1973. The production is divided between the Central Oregon Pumice Company, which has several active pits west of and within a few miles of Bend (Figure 47) and the Cascade Pumice Company, which mines from large open pits just southwest of Tumalo. Both companies utilize inexpensive open-pit mining methods, using large front-end loaders to excavate pit-run material, which is trucked to nearby screening and loading facilities (Figure 48). The Central Oregon Pumice plant is in Bend, and the Cascade Pumice plant is at Deschutes Junction, about halfway between Bend and Redmond on Highway 97.

Both pumice companies also produce red or black cinders from local sources in a variety of sizes and have the ability to market either pumice or cinders or a blend of the two materials, which can be used in manufacturing concrete blocks. Almost all of the sized pumice and specialty products are shipped by rail to customers throughout the Pacific Northwest including western Canada.

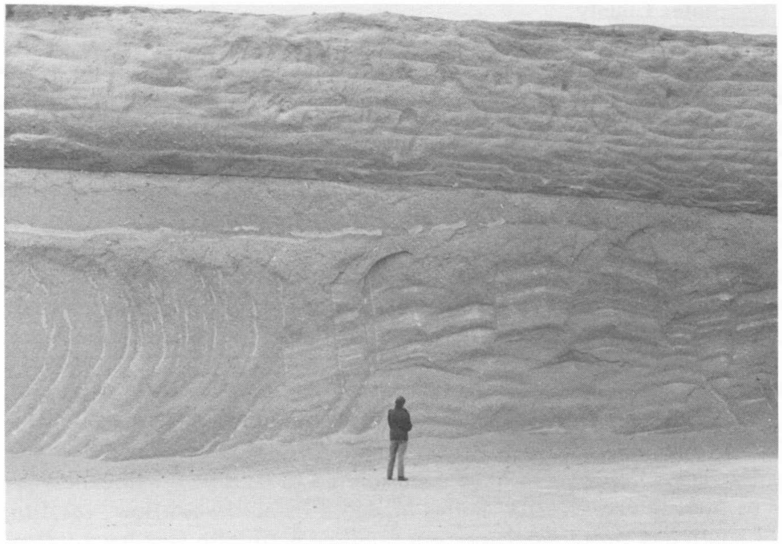


Figure 47. Working face at a pit operated by the Central Oregon Pumice Company at the Bend pumice deposit. Minable thickness of white lump pumice is about 25 feet (8 m).

Figure 48. At Central Oregon Pumice Co. pit, after removal of overburden, mining of pumice is accomplished by large front-end loaders and dump trucks. Truck driver generally also operates the loader.

Pumice deposits of Deschutes County

Bend pumice deposit: The Bend pumice deposit is a layer of ash-flow tuff, as much as 40 feet thick, which may extend over at least 30 square miles. It is the second from the bottom of a series of five ash-flow tuffs (see Figure 15) which originated as a quick succession of violent eruptions from an unknown volcanic vent in the Broken Top-South Sister area. Either the heat of the ash flow was not great or it was quickly dissipated before the particles came to rest, for the deposit has little or no induration or welding, in contrast to the other ash-flow tuffs, and can be easily excavated.

The individual pumice fragments are tightly packed, however, and can stand as a vertical wall without slumping. Fragments range in size from less than one millimeter to 15 centimeters (6 inches), averaging 3 to 5 millimeters ($\frac{1}{4}$ inch). They are holohyaline (glass) pumice, with only occasional small feldspar crystals, showing virtually no alteration or devitrification. They are white to light gray and appear silky and fibrous.

The contact between the Bend pumice and the overlying ash-flow tuff is commonly marked by a few inches of fine ash, white to pink, that makes a smooth horizontal or slightly curved line on the walls of the pits (Figure 49).

The Bend pumice deposit appears to have accumulated to its greatest thickness just west of Bend, where the presence of Awbrey and Overturf Buttes hindered its northward flow, resulting in a thicker-than-average layer to the south and west. Faulting near Laidlaw Butte also may have influenced the thickness of the pumice deposit in this area. In many areas the deposit is covered by ash flows, lava flows, sand and gravel, and surficial debris.

Mining has been concentrated near Bend and at Tumalo, both of which still contain large reserves estimated to be about a 50-year supply. Detailed prospecting probably will add to the known reserves. Current and future open-pit mining of pumice will require reclamation plans. Many of the older pits have been abandoned; a few are being reclaimed as landfill sites (Figure 50).

Block pumice deposits: Large lumps and blocks of pumice occur at two locations in the County. Block pumice has been mined and marketed from the central pumice cone area in the Newberry caldera for many years. Chunks of pumice of good quality are sorted from talus deposits on the east flank of the cone and are mined from massive pumiceous zones associated with the small obsidian dome in the center of the cone. Production has been one to a few carloads each year.

Large quantities of block pumice occur in the near-surface portion of the large obsidian flow at Rock Mesa, in the South Sister area of the High Cascades. The pumice appears to be of commercial quality; however, Rock Mesa is within the Three Sisters Wilderness, and the validity of a group of 10 mining claims owned by the U. S. Pumice Company is being questioned by the U. S. Forest Service.

Volcanic cinders and scoria

Volcanic cinders are the reddish-to-black vesicular fragments that pile up during explosive eruptions of basaltic magma. Most deposits of cinders occur as cones or mounds of stratified fragments that range in size from a fraction of an inch to several inches in diameter. By definition, cinders are essentially uncemented, juvenile glassy and vesicular ejecta ranging chiefly from 4 to 32 mm in diameter. The fragments over 32 mm (about $1\frac{1}{4}$ inches) should technically be called scoria. Individual cones or mounds of cinders and scoria may be several hundreds of feet in diameter and as much as 500 feet (150 m) high (Figure 10).

Cinders and scoria continue to be one of the most important road building and maintenance materials for the extensive network of secondary and logging roads in Deschutes County. It is estimated that nearly 900,000 cubic yards were used during 1973. At least half of the production was used for surfacing and maintenance of roads used by loggers in the Deschutes National Forest. Large quantities were also used by the State Highway Department, County Road Department, and private contractors for road building, maintenance, and winter road sanding. About 100,000 cubic yards were mined, crushed, and screened by the large pumice producing companies for export, mainly as concrete aggregate. Smaller amounts are sold for roofing granules and landscape ground covers. Blocks of agglutinate and large bombs associated with the layered cinder deposits also have some marketability for landscaping.

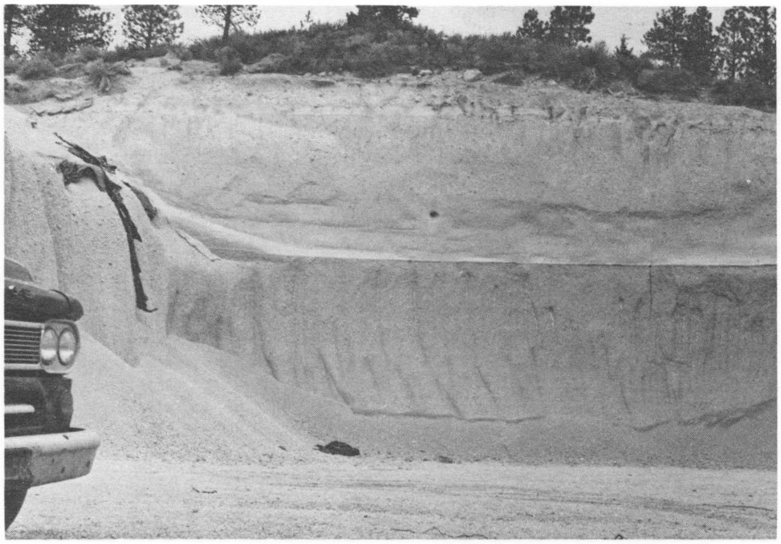


Figure 49. A thin layer of fine-grained pink ash marks the contact between the underlying Bend pumice deposit and the Tumalo ash-flow tuff.

Figure 50. Some of the abandoned pumice pits like the one shown here are being used for solid waste disposal.

A large number of conveniently located cinder pits have been established throughout the County. The locations of most of these are shown on the Mineral Locality Map and listed in Table 1. Only a few of the established pits are active at any one time, depending on road building or maintenance activity in the vicinity. Most of the pits in the western part of the County are in the Deschutes National Forest, and those in the eastern part are generally on lands administered by the Bureau of Land Management, while the largest producing pits in the northern part of the County are on privately owned land. Earlier mining practices whereby large pits with steep vertical walls were developed at the base of a cinder cone or mound (Figure 51) have been modified; now, at least those operations within the Deschutes National Forest are started near the tops of the cones, and reclamation of the surface progresses with mining (Figure 52). This method allows mining of most of the available material, without creating hazardous steep slopes.

Almost any of the innumerable cinder cones and mounds shown on the geologic map are potential sources of usable cinders and scoria. Deschutes County has an adequate supply of this type of construction material for all forseeable future uses.

Sand and Gravel and Crushed Stone

General discussion

Nationwide, about 95 percent of all sand and gravel produced is used in the construction industry, with slightly over half this total in road building and the associated bridges, overpasses, and interchanges. The remainder is used in buildings (private and public) and such appurtenances as driveways and parking lots.

Sand and gravel as aggregate can be loosely defined as the more or less rounded rock fragments (silt, sand, pebbles, cobbles, and boulders) generated mainly by physical weathering processes and transported by the agents of erosion, mainly running water, and usually deposited rapidly in thick-to-massive deposits that are crudely layered and sorted. Abrasion of the rock fragments during stream transport usually insures that the ones that remain will be somewhat sound and durable and usable as an aggregate for asphaltic or portland cement concrete.

Specifications to determine sand and gravel quality or suitability for a certain use are highly variable and depend on the specifying agency or the material available. One or more of the following physical or chemical properties may be significant:

1. Reaction of the aggregate to freezing or thawing
2. Chemical reaction with cement
3. Resistance to abrasion and impact
4. Gradations in size
5. Deleterious constituents (ash, clay, organic material, etc.)

The maximum size acceptable for "gravel" is about 3 inches, and since most occurrences commonly found in Deschutes County contain cobbles and boulders greater than 3 inches, crushing is usually required for total utilization. Contaminants such as clay coating the fragments, chemical salts, organic matter, or weathered particles may require washing or other processing to remove them.

"Crushed stone" substitutes for sand and gravel and is produced in the required sizes by crushing and screening of competent rock types.

This report does not represent a detailed study of the sand and gravel resources of Deschutes County; however, the field reconnaissance, air-photo interpretation, and information received from aggregate producers and users show that large quantities of usable sand and gravel are present. For the near future, sand and gravel deposits in locations convenient to the markets appear to be adequate; however, unless reserves near growing urban areas are protected by zoning, they may be reduced or eliminated, resulting in longer hauls from other locations and increased construction costs.

Figure 51. Large cinder pit in sec. 33, T. 14 S., R. 13 E., at south end of Tetherow Butte. Cinders have been dug here intermittently since about 1940, furnishing Redmond and environs with tremendous quantities of aggregate.

Figure 52. Active cinder pit (1974) has portable screening and loading facility. Near top of Little Pistol Butte. Slopes are smoothed as material is mined.

Aggregate needs for Deschutes County

Most of the population of the County is concentrated in two areas: 1) the triangular area that includes Bend, Redmond, Sisters, Tumalo, and Terrebonne, and 2) the north-south corridor that includes Lapine. These areas have shown the most rapid growth in the past and are predicted to grow at a faster rate than the rest of the County. The projected population for the County to the year 2000, as estimated by the Center For Population Research and Census at Portland State University, will be more than double that of 1970.

A canvas of the largest sand and gravel producers and users shows that in 1973 about 400,000 cubic yards were produced, and in 1974 production had increased to about 460,000 cubic yards. From the above statistics, per capita use is estimated to be about 12 cubic yards. If the high population growth predictions for the County are accurate, by 1990 Deschutes County will be using about 725,000 cubic yards of sand and gravel, including crushed rock, per year, and for the 15 years from 1975 to 1990 the County will have used up about 9,000,000 cubic yards of material (Figure 53).

All known sources of sand and gravel are shown on the Mineral Resources Map and listed in Table 1 with short comments about quantity and quality.

Sand and gravel reserves

Bend-Redmond area: Most of the sand and gravel for the Bend community has been supplied from two areas between Bend and Tumalo. Flood plain and channel gravels of the Deschutes River at Tumalo have furnished the largest quantities and best quality in the past (Figures 54 and 55). Older terrace and previous stream-channel gravels adjacent to Tumalo Creek near its confluence with the Deschutes River northwest of Awbrey Butte have been developed and have furnished large quantities of sand and gravel in recent years (Figures 56 and 57).

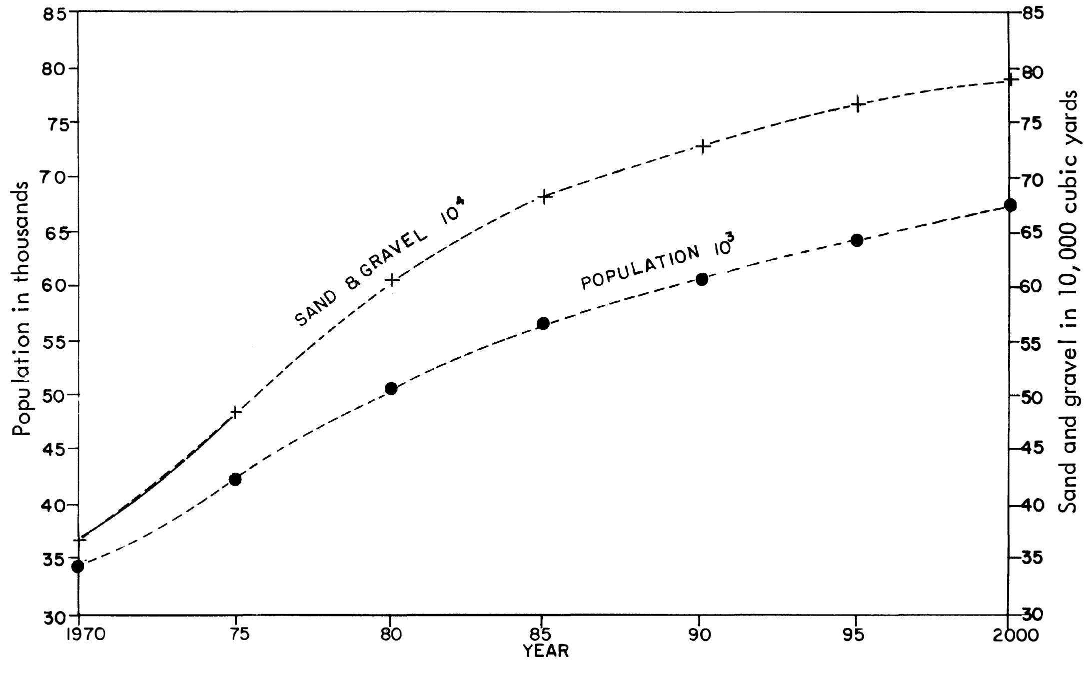


Figure 53. Projected population growth and sand and gravel consumption in Deschutes County for the period 1970 to 2000. Population estimates from Center for Population Research and Census, Portland State University. Sand and gravel estimates based on per capita use of 12 cubic yards per year.

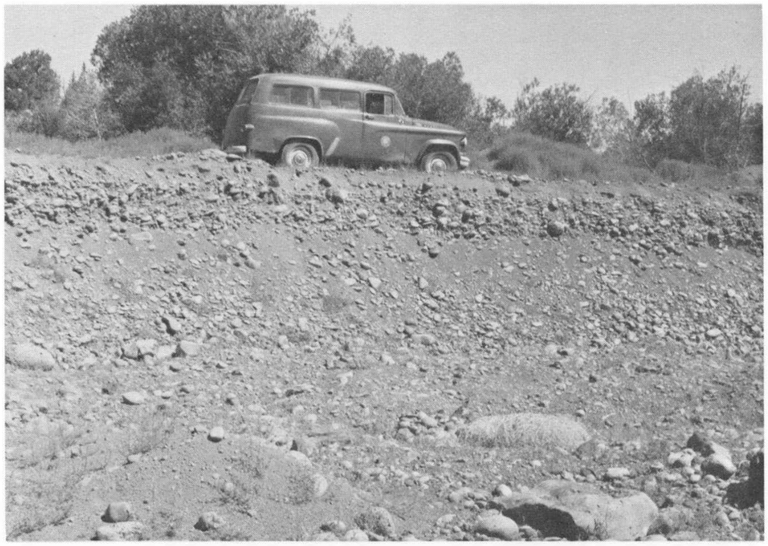


Figure 54. Flood plain and streambank gravels adjacent to Deschutes River north of Tumalo can be mined to depths of 10 or 15 feet (4 or 5 m). Gravels are poorly sorted, containing many large boulders and a high percentage of fine, ashy, and pumiceous material.

Figure 55. Sand and gravel pit near Johnson Road south of Tumalo, in sec. 6, T. 17 S., R. 12 E. Glaciofluvial fan gravels are overlain by 6 to 12 feet (2 to 4 m) of pumiceous sand and soil and underlain by the pinkish ash-flow tuff unit.

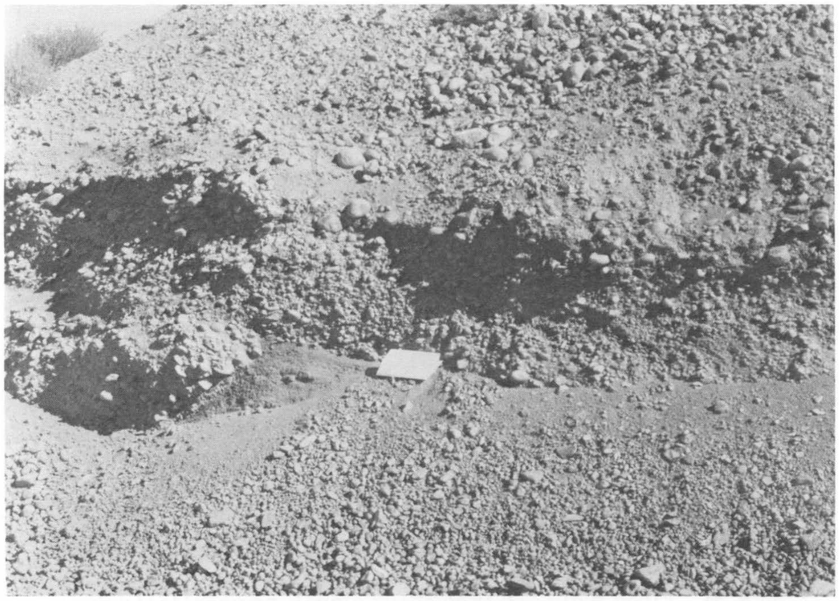


Figure 56. Gravel bank on a terrace between Tumalo Creek and the Deschutes River. Old stream-channel gravels may be as much as 30 feet (10 m) thick. Contains some cobbles as much as 6 feet (2 m) in size and lenses of pumiceous sand and silt.

Figure 57. Modern portable crushing, screening, and washing plant of Deschutes Ready Mix Sand & Gravel Co. can produce large quantities of sized material. Pit is in NW$\frac{1}{4}$ sec. 18, T. 17 S., R. 12 E.

Within 10 miles southwest of Bend, large quantities of sand and gravel of glaciofluvial origin are present in several localities adjacent to the Cascade Lakes Highway. Some evaluation of these largely undeveloped sand and gravel deposits has been done, and minor quantities have been used for nearby roads and highways. Reserves are reported to be at least a few million cubic yards in this area.

Glaciofluvial gravels are also present in large quantities in the area from Plainview to Sisters, with the thickest, best quality materials in the Squaw Creek flood plain southeast of Sisters (Figure 58). Glacially generated clastic materials have been distributed to the flat area adjacent to U. S. Highway 20 and Oregon Highway 126 west and northwest of Sisters. The 15- to 20-mile haul of these gravels to the urban centers of Bend or Redmond will increase transportation cost to the user.

The Redmond community is supplied mainly from the deposits along the Deschutes River at Tumalo and old channel gravels in Deep Canyon near Fryear Butte. A small deposit of Deschutes channel gravels near Lower Bridge is also furnishing some aggregate. The largest reserves close to Redmond are reported to be near Tetherow Bridge in sec. 36, T. 14 S., R. 12 E., where old channel gravels reworked from the Deschutes Formation cover about 100 acres. The gravel appears to have a minable depth of at least 10 feet and consists mainly of rounded basaltic pebbles, cobbles, and boulders averaging about 3 to 4 inches in diameter. As in most other gravel deposits, 40 to 50 percent of the material is fine, and much of it may have to be rejected.

No doubt former stream-channel sand and gravel deposits lie beneath lava flows or ash-flow tuffs west and northwest of Bend, and the Deschutes Formation also may contain some zones of gravel farther north that will contribute reserves for future needs.

Eastern Deschutes County: In the eastern part of the County, an area around Alfalfa, adjacent to Dry River, appears to contain enough fair-quality sand and gravel for current and near-future needs. In Millican Valley, gravel fans from drainages on the northeast flanks of Newberry Volcano and Pleistocene lakeshore gravel deposits adjacent to U. S. Highway 20 can furnish material for road maintenance and resurfacing. Gravel fans deposited along the southwest flanks of Hampton Buttes have some reserves of crusher-run materials (Figure 59).

Southern and western Deschutes County: In the southern part of the County adjacent to U. S. Highway 97, in the Lapine area, thick layers of poorly sorted cindery gravel provide some material suitable for fill and base rock. A limited supply of better quality gravel occurs along lower Paulina Creek. To the west, glacial outwash and glaciofluvial materials are abundant, especially in the area from Wickiup to Crane Prairie Reservoir.

Good-quality sand and gravel deposits are not unlimited. Costs will be influenced by length of haul to the market, land reclamation restrictions, and regulations required to curb air and water pollution.

Crushed stone reserves

The minor production (17,000 cubic yards in 1974) of crushed stone and few quarry sites (shown on the Mineral Location Map) indicate the lack of known deposits of good-quality stone suitable for aggregate. The newly opened quarry on Cline Buttes has ample reserves of flow-banded rhyolite that can be crushed, screened, and marketed for some aggregate uses.

Of the other near-surface rock types, the Pliocene-Pleistocene non-vesicular basaltic lava flows with platy jointing may be the most suitable to crush for an acceptable aggregate. Most of these basalt flows are thin, however, and quarry sites that have the potential of producing large quantities of rock are scarce. If sand and gravel reserves are eventually depleted, a search may have to be made to find better and larger crushed-stone sources.

Figure 58. Bouldery glacial gravel in channel of Squaw Creek south of Sisters. Large quantities of glaciofluvial sand and gravel cover the flat areas adjacent to Squaw Creek in this area.

Figure 59. Stockpiles of crushed and screened aggregate from broad shallow pits in an alluvial fan type of sand and gravel deposit near Hampton.

Surface Soil and Common Fill Material

Common or select fill materials are generally surface soils or those mixed materials that do not meet the specifications for sand and gravel but are suitable for roadway shoulders, backfilling of ditches and trenches that carry such underground utilities as water and sewer lines and power and telephone cables, and for general fill. In most regions, such materials are usually abundant and available as surface deposits and are not considered an important resource. In Deschutes County, however, common fill is lacking within and adjacent to the population centers because lava flows are too near the surface for thick soil zones to exist (see Figure 18), and fill material is limited to the few localities discussed below.

Well logs indicate that relatively fine-grained volcanic sediments are present under the young lavas at variable depths. In a few places the young lavas did not cover these sediments and they are present at the surface, as at the Knott Pit, about 5 miles southeast of Bend (S$\frac{1}{2}$ sec. 14, T. 18 S., R. 12 E.). Here the materials have been excavated for use as fill since about 1953. The pit has been greatly expanded in the past few years and now serves as the City-County sanitary landfill. Large quantities, estimated to be as much as 100,000 cubic yards per year are excavated to make room for the landfill and for sale and use as fill at construction projects in the Bend area. The thinly layered and cross-bedded volcanic sediments (Figure 60) are partially indurated but still easily dug with caterpillar tractor, back hoe, or front-end loader. The County supervises the sanitary landfill and sells the fill material. Large users of fill from this source are the State Highway Department, County Road Department, City of Bend Water Department, and local utility contractors.

Amazingly at the Knott Pit site, excavation of the sediments reached 90 feet below the surface before encountering a lava flow. It appears that surrounding the Knott Pit there are several hundred acres underlain by a thick section of volcanic sediments suitable for fill, representing a large quantity of a valuable resource.

The Anderson clay pit west of Bend in the SW$\frac{1}{4}$, sec. 25, T. 17 S., R. 11 E., has also furnished backfill and surface fill materials from an alluvial deposit which contains considerable quantities of pumice and clay. This source represents a large supply of fill for certain uses.

In the Redmond area, soil zones are somewhat thicker and the cindery soil around Tetherow Buttes could furnish fill material for the Redmond area. Two small areas of volcanic sediments that could probably produce usable fill were noted south of Forked Horn Butte in sec. 31, T. 15 S., R. 13 E., and in secs. 1 and 6, T. 16 S., R. 12-13 E. These occurrences were not examined in detail so the quantity and quality of the material is not known.

Figure 60. Knott sanitary landfill pit southeast of Bend furnishes large quantities of common fill materials used in the Bend area.

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APPENDIX: INDUSTRIAL MINERAL OCCURRENCES IN DESCHUTES COUNTY, OREGON

Map No.	Type of Material	Location			Quadrangle	Name-information	References
		sec.	T. S.	R. E.			
1	Cinders & scoria	9	14	8	Three Finger Jack 15'	Cashe Mt.-currently inactive	USFS Sisters Dist.
2	Sand & gravel	NW 5	14	9	Sisters 15'	Glacial outwash, inactive	This study
3	Sand & gravel	NW 4	14	9	Sisters 15'	Glacial outwash, inactive	This study
4	Sand & gravel	NE 8	14	9	Sisters 15'	Black Butte-glacial outwash	USFS Sisters Dist.
5	Cinders & scoria	SW 17	14	9	Sisters 15'	Fivemile Butte-not active	USFS Sisters Dist.
6	Cinders & scoria	NE 32	14	9	Sisters 15'	Fourmile Butte-Pleistocene cinder	OSHD-USFS
7	Sand & gravel	SW 19	14	10	Sisters 15'	Hwy 126-glacial outwash	OSHD
8	Cinders & scoria	19	14	10	Sisters 15'	Zimmerman Butte-active large pit, large reserves	OSHD-USFS
9	Cinders & scoria	4	14	10	Sisters 15'	Garrison Butte	USFS
10	Clay	15	14	10	Sisters 15'	Edgar Clay Deposit-gray to dark gray mixed clays	USFS
11	Sand & gravel	NW 33	14	10	Sisters 15'	Lundy Road-layered cindery sand and gravel, glacial outwash	This study
12	Sand & gravel	SW 33	14	10	Sisters 15'	Gun club-medium size material, shallow pit	This study
13	Diatomite	16	14	12	Cline Falls $7\frac{1}{2}$'	Lower Bridge Diatomite (see text)	This study
14	Sand & gravel	15, 16	14	12	Cline Falls $7\frac{1}{2}$'	Lower Bridge-shallow terrace, gravels overlie diatomite	OSHD
15	Cinders & scoria	SE 18	14	13	Redmond $7\frac{1}{2}$'	Deschutes Co.-large well developed pit	MLR, OSHD, This study
16	Cinders & scoria	NW 16	14	13	Redmond $7\frac{1}{2}$'	C. A. Loe-large pit	MLR, OSHD
17	Cinders & scoria	NW 29	14	13	Redmond $7\frac{1}{2}$'	E. A. Moore-north end of Tetherow Butte	MLR, OSHD
18	Cinders & scoria	NW 28	14	13	Redmond $7\frac{1}{2}$'	M&M Rock Co.-Tetherow Butte NE	MLR, OSHD
19	Cinders & scoria	NW 33	14	13	Redmond $7\frac{1}{2}$'	Grote Pit-Tetherow Butte SW	MLR, OSHD
20	Cinders & scoria	SW 33	14	13	Redmond $7\frac{1}{2}$'	City Pit-Tetherow Butte S	MLR, OSHD
21	Cinders & scoria	NE 33	14	13	Redmond $7\frac{1}{2}$'	Mid-Oregon Pit-Tetherow Butte SE	MLR, OSHD
22	Sand & gravel	$S\frac{1}{2}$ 36	14	13	Redmond $7\frac{1}{2}$'	Tetherow Rd. Pit-reports indicate 100 ac of good quality gravel	This study
23	Sand & gravel	SW 16	15	13	Redmond $7\frac{1}{2}$'	Deschutes Fm.-only fair quality	OSHD
24	Cinders & scoria	NW 29	15	13	Forked Horn Butte $7\frac{1}{2}$'	Limited supply and quality?	OSHD
25	Sand & gravel	SE 11	15	12	Cline Falls $7\frac{1}{2}$'	Terrace gravels, good quality	OSHD
26	Sand & gravel	NE 14	15	12	Cline Falls $7\frac{1}{2}$'	Terrace gravels, good quality	OSHD
27	Quarry rock	SW 16	15	12	Cline Falls $7\frac{1}{2}$'	Cline Buttes-banded rhyolite, large supply	MLR, This report
28	Cinders & scoria	W 18	15	12	Cline Falls $7\frac{1}{2}$'	Not active, small pit	OSHD
29	Sand & gravel	9	15	11	Henkle Butte $7\frac{1}{2}$'	Deep canyon, active pit, good quality	OSHD
30	Sand & gravel	5	15	11	Henkle Butte $7\frac{1}{2}$'	Cloverdale-fine materials, only fair quality	OSHD
31	Cinders & scoria	NE 12	15	10	Henkle Butte $7\frac{1}{2}$'	Cyrus Pit-large cinder pit, reserves unknown	MLR, This study
32	Sand & gravel	NE 11	15	10	Sisters 15'	Squaw Creek-outwash, good quality	OSHD
33	Sand & gravel	9	15	10	Sisters 15'	Weigh Station-Squaw Creek outwash	USFS,OSHD
34	Sand & gravel	16	15	10	Sisters 15'	Squaw Creek-outwash gravels	OSHD
35	Quarry rock	21	15	10	Broken Top 15'	No name, platy basalt	USFS
36	Cinders & scoria	SW 4	16	9	Broken Top 15'	Pole Creek	USFS
37	Quarry rock	11	16	9	Broken Top 15'	Squaw Creek-basalt	USFS
38	Cinders & scoria	SW 12	16	9	Broken Top 15'	Melvin Butte	USFS
39	Cinders & scoria	SE 15	16	9	Broken Top 15'	Black Pine	USFS
40	Sand & gravel	$W\frac{1}{2}$ 36	15	10	Tumalo Dam $7\frac{1}{2}$'	Plainview-quantity or extent unknown	OSHD
41	Cinders & scoria	SE 10	16	11	Tumalo Dam $7\frac{1}{2}$'	Large pit, more available	OSHD
42	Cinders & scoria	S 12	16	11	Tumalo $7\frac{1}{2}$'	Small privately owned pit	This study
43	Sand & gravel	SE 11	16	12	Tumalo $7\frac{1}{2}$'	Peterson Road-small deposit, layered fine to coarse; Deschutes Fm.-poor to fair quality	OSHD
44	Cinders & scoria	22	16	12	Tumalo $7\frac{1}{2}$'	Long Butte-large supply available	OSHD
45	Cinders & scoria	22	16	12	Tumalo $7\frac{1}{2}$'	Long Butte-large supply available	MLR
46	Quarry rock	22	16	12	Tumalo $7\frac{1}{2}$'	Inactive, platy basalt	OSHD
47	Sand & gravel	30	16	12	Tumalo $7\frac{1}{2}$'	Bend Aggregate-reworked Deschutes Fm. river terrace	OSHD
48	Sand & gravel	29	16	12	Tumalo $7\frac{1}{2}$'	Bend Aggregate-river terrace, large supply, good quality	OSHD
49	Sand & gravel	31	16	12	Tumalo $7\frac{1}{2}$'	" " "	OSHD

APPENDIX (Continued)

Map	Type of	Location					
No.	Material	sec.	T. S.	R. E.	Quadrangle	Name-information	References
50	Cinders & scoria	NW 36	16	11	Tumalo $7\frac{1}{2}$'	Laidlaw Butte-active pit	This study
51	Pumice	1, 2, 35, 36	16	11	Tumalo $7\frac{1}{2}$'	Cascade Pumice-active pits, ash-flow pumice, south of Laidlaw Butte	This study
52	Sand & gravel	SW 6	17	12	Tumalo $7\frac{1}{2}$'	Terrace gravels, good quality, partly removed	OSHD
53	Sand & gravel	12	17	12	Bend $7\frac{1}{2}$'	Thick good quality gravels	OSHD
54	Sand & gravel	NW 18	17	12	Bend $7\frac{1}{2}$'	Deschutes Redi Mix S&G-large quantity, fair to good quality	This study
55	Sand & gravel	S$\frac{1}{2}$ 12	17	11	Bend $7\frac{1}{2}$'	" " "	This study
56	Cinders & scoria	NE 23	17	11	Bend $7\frac{1}{2}$'	Tumalo Butte-not active	This study
57	Cinders & scoria	NW 2	17	9	Broken Top 15'	Three Creek	USFS
58	Cinders & scoria	16	17	10	Broken Top 15'	Triangle Hill	USFS
59	Quarry rock	23	17	12	Bend $7\frac{1}{2}$'	Small quarry, Pleistocene basalt	OSHD
60	Sand & gravel	NE 26	17	14	Alfalfa $7\frac{1}{2}$'	Dry River-outwash, 10' thick, pebbly gravel, fine to medium	This study
61	Quarry rock	32	17	13	Bend Airport $7\frac{1}{2}$'	Small quarry, Badlands Lava flows	OSHD
62	Cinders & scoria	33, 34	17	12	Bend $7\frac{1}{2}$'	Pilot Butte Cone-black cinders, limited use	OSHD
63	Pumice, clay, cinders	SE 25	17	11	Bend $7\frac{1}{2}$'	D.B. Anderson-pit run materials	This study
64	Pumice	S$\frac{1}{2}$ 35, 36	17	11	Bend $7\frac{1}{2}$'	Central Oregon Pumice-active pumice production	This study
65	Sand & gravel	3	18	11	Shevlin Park $7\frac{1}{2}$'	Mainline-thin, only fair quality gravels	OSHD, USFS
66	Building stone	NE 10	18	11	Shevlin Park $7\frac{1}{2}$'	Active quarry, black ash-flow tuff stone	This study
67	Pumice	11	18	11	Shevlin Park $7\frac{1}{2}$'	Central Oregon Pumice-extensive pumice deposits	This study
68	Sand & gravel	4	18	11	Shevlin Park $7\frac{1}{2}$'	Skyline Road-thin outwash gravels, mostly removed	OSHD, USFS
69	Cinders & scoria	18	18	11	Shevlin Park $7\frac{1}{2}$'	Swede Ridge	USFS
70	Cinders & scoria	13	18	10	Shevlin Park $7\frac{1}{2}$'	Swede Ridge #2	USFS
71	Cinders & scoria	10	18	10	Broken Top 15'	East Tumalo	USFS
72	Cinders & scoria	W$\frac{1}{2}$ 18	18	9	Broken Top 15'	Todd Creek-no development	USFS
73	Cinders & scoria	SW 18	18	9	Broken Top 15'	Todd Creek #2-active pit	USFS
74	Cinders & scoria	28, 29	18	9	Bachelor Butte $7\frac{1}{2}$'	Red Butte	USFS
75	Cinders & scoria	4	19	8	Elk Lake $7\frac{1}{2}$'	Red Crater	USFS
76	Cinders & scoria	S$\frac{1}{2}$ 30	18	10	Wanoga Butte $7\frac{1}{2}$'	Sand shed, active pit	USFS
77	Cinders & scoria	SE 6	19	10	Wanoga Butte $7\frac{1}{2}$'	Katalo Butte	USFS
78	Cinders & scoria	3	19	10	Wanoga Butte $7\frac{1}{2}$	Kiwa Butte-inactive	USFS
79	Not used	-	-	-	-	-	-
80	Cinders & scoria	30, 31	18	11	Benham Falls $7\frac{1}{2}$'	Brooks Scanlon Pit-not active	USFS
81	Cinders & scoria	28	18	11	Benham Falls $7\frac{1}{2}$'	Central Oregon Pumice-cinder pit	This study
82	Sand & gravel	21	18	11	Benham Falls $7\frac{1}{2}$'	Flagstone-glacial outwash	OSHD, USFS
83	Sand & gravel	15, 22	18	11	Shevlin Park $7\frac{1}{2}$'	Central Oregon Pumice-gravel pit	This study
84	Cinders & scoria	35, 36	18	11	Lava Butte $7\frac{1}{2}$'	Lava	USFS
85	Cinders & scoria	30	18	12	Lava Butte $7\frac{1}{2}$'	Weigh Station-cinder mound, small source	This study
86	Cinders & scoria	NE 21	18	12	Bend $7\frac{1}{2}$'	Central Oregon Pumice-good quality, large supply	OSHD
87	Silt, sand & gravel	S$\frac{1}{2}$ 14	18	12	Bend $7\frac{1}{2}$'	Volcanic sediments, fine to coarse, fill material removed for sanitary landfill	This study
88	Cinders & scoria	3, 10	19	12	Lava Butte $7\frac{1}{2}$'	Bessie Butte	USFS
89	Cinders & scoria	NE 36	18	12	Kelsey Butte $7\frac{1}{2}$'	Horse Butte-large quantity of good quality avaliable	USFS
90	Cinders & scoria	SE 1	19	12	Kelsey Butte $7\frac{1}{2}$'	Cabin Butte-large quantity of good quality avaliable	USFS
91	Cinders & scoria	SE 6	19	13	Kelsey Butte $7\frac{1}{2}$'	Coyote Butte-red cinders, large supply	USFS
92	Sand & gravel	31	18	14	Horse Ridge $7\frac{1}{2}$'	Fine materials, small quantity borrow pits	OSHD
93	Sand & gravel	11	19	14	Horse Ridge $7\frac{1}{2}$'	Gravel fan from Dry River, large quantity, fair quality	OSHD
94	Cinders & scoria	16	19	15	Millican $7\frac{1}{2}$'	Reserves not known	OSHD
95	Sand & gravel	25, 26	19	14	Horse Ridge $7\frac{1}{2}$'	Borrow material, reworked lake sediments	OSHD
96	Sand & gravel	NW 3	20	14	Evans Well $7\frac{1}{2}$'	Borrow pit, gravel fan, fair quality	This study

APPENDIX (Continued)

Map No.	Type of Material	Location sec.	T. S.	R. E.	Quadrangle	Name-information	References
97	Sand & gravel	SE 36	19	13	Horse Ridge 7½'	Borrow pit, fair med. to fine gravel	This study
98	Cinders & scoria	SW 16	19	12	Lava Butte 7½'	Lava River-eroded cinder mound, inactive	USFS
99	Cinders & scoria	SE 18	19	12	Lava Butte 7½'	East Lava Butte-inactive	USFS
100	Cinders & scoria	33, 34	19	12	Lava Butte 7½'	Klawhop Butte-not active	USFS
101	Cinders & scoria	34	19	11	Benham Falls 7½'	N. Camp Abbott-mostly removed	USFS
102	Cinders & scoria	SE 3	20	11	Benham Falls 7½'	Camp Abbott-active, large supply	USFS
103	Cinders & scoria	19	19	11	Benham Falls 7½'	Boundary, small pit	USFS
104	Cinders & scoria	24	19	9	Wanoga Butte 7½'	Dutchman Creek-developed	USFS
105	Cinders & scoria	24	19	9	Wanoga Butte 7½'	Dutchman Creek #2-status unknown	USFS
106	Cinders & scoria	NE 36	19	9	Bachelor Butte 7½'	Sheridan-not active	USFS
107	Sand & gravel	4	20	8	Crane Prairie 7½'	Deschutes Bridge-glacial outwash, extent & quantity not known	USFS
108	Cinders & scoria	31	19	9	Bachelor Butte 7½'	Sheridan #2	USFS
109	Cinders & scoria	6	20	9	Round Mt. 7½'	Loop	USFS
110	Cinders & scoria	5	20	9	Bachelor Butte 7½'	1945	USFS
111	Cinders & scoria	5	20	9	Round Mt. 7½'	Junction	USFS
112	Cinders & scoria	5	20	9	Round Mt. 7½'	Junction #2	USFS
113	Cinders & scoria	35	19	9	Wanoga Butte 7½'	North End	USFS
114	Cinders & scoria	SE 11	20	9	Pistol Butte 7½'	Lolo Butte-active pit	USFS
115	Cinders & scoria	4	20	10	Pistol Butte 7½'	Straight	USFS
116	Cinders & scoria	4	20	10	Pistol Butte 7½'	Straight #2-developed	USFS
117	Cinders & scoria	34	19	10	Wanoga Butte 7½'	Fire Break	USFS
118	Cinders & scoria	11	20	10	Anns Butte 7½'	Little Ann-active pit	USFS
119	Cinders & scoria	19, 20	20	10	Pistol Butte 7½'	Pistol Pit-used in 1974, active, large quantity	USFS
120	Cinders & scoria	15	20	9	Round Mt. 7½'	Ridge	USFS
121	Cinders & scoria	17	20	9	Round Mt. 7½'	Lumrum Butte	USFS
122	Cinders & scoria	19	20	9	Round Mt. 7½'	North Cone	USFS
123	Cinders & scoria	19	20	9	Round Mt. 7½'	South Cone	USFS
124	Cinders & scoria	30	20	9	Round Mt. 7½'	Lookout Mt.	USFS
125	Sand & gravel	14	20	8	Round Mt. 7½'	Lodgepole	USFS
126	Sand & gravel	23	20	9	Round Mt. 7½'	Flat	USFS
127	Sand & gravel	21	20	8	Crane Prairie Res. 7½'	Deschutes River	USFS
128	Sand & gravel	22	20	8	Crane Prairie Res. 7½'	Snow Creek	USFS
129	Sand & gravel	30	20	8	Crane Prairie Res. 7½'	Cultus Junction	USFS
130	Sand & gravel	30	20	8	Crane Prairie Res. 7½'	Cultus Creek	USFS
131	Sand & gravel	36	20	7	Crane Prairie Res. 7½'	Spruce	USFS
132	Sand & gravel	1	21	7	Crane Prairie Res. 7½'	Quinn	USFS
133	Cinders & scoria	4	21	7	Irish Mountain 7½'	Lemish	USFS
134	Quarry rock	34	21	7	The Twins 7½'	Annex	USFS
135	Sand & gravel	NE 36	21	7	Davis Mt. 7½'	West Browns Creek	USFS
136	Sand & gravel	NE 36	21	7	Davis Mt. 7½'	East Browns Creek	USFS
137	Cinders & scoria	6	22	8	Davis Mt. 7½'	#217-not developed	USFS
138	Cinders & scoria	SW 14	22	7	Davis Mt. 7½'	Pine Butte-active pit, good quality	USFS
139	Cinders & scoria	NE 22	22	7	Davis Mt. 7½'	North Davis Mt.-active pit, red cinders	USFS
140	Sand & gravel	NW 28	21	8	Davis Mt. 7½'	Sheep Bridge	USFS
141	Cinders & scoria	16	21	8	Crane Prairie Res. 7½'	Crater & Crater #2-developed	USFS
142	Cinders & scoria	16	21	8	Crane Prairie Res. 7½'	Dam	USFS
143	Cinders & scoria	9, 10	21	8	Crane Prairie Res. 7½'	Shuckash	USFS
144	Cinders & scoria	10	21	8	Crane Prairie Res. 7½'	Palanush	USFS
145	Cinders & scoria	6, 7	21	9	Round Mt. 7½'	Round Mt. Pass-active pit	USFS
146	Cinders & scoria	E½ 13	21	8	Round Mt. 7½'	Round Mt.	USFS
147	Cinders & scoria	33	20	9	Round Mt. 7½'	South Dry Butte	USFS
148	Cinders & scoria	SW 34	20	9	Round Mt. 7½'	Addition	USFS
149	Cinders & scoria	SW 34	20	9	Round Mt. 7½'	1808	USFS
150	Cinders & scoria	SW 34	20	9	Round Mt. 7½'	1808 #2	USFS
151	Quarry rock	14	21	9	LaPine 7½'	Pringle Falls	USFS
152	Cinders & scoria	NW 36	21	9	LaPine 7½'	Cruiser Butte	USFS
153	Sand & gravel	25	20	10	Anns Butte 7½'	Gassner-pit run, fill	USFS
154	Sand & gravel	NE 6	21	11	Anns Butte 7½'	Med. to fine, poor quality	OSHD
155	Sand & gravel	NW 5	21	11	Anns Butte 7½'	Hwy 97 #13-mostly fine, fair to poor quality, pebbly gravel	OSHD, USFS
156	Sand & gravel	SW 5	21	11	Anns Butte 7½'	Hwy 97 #14-mostly fine, fair to poor quality, pebbly gravel	OSHD, USFS

APPENDIX (Continued)

Map No.	Type of Material	Location			Quadrangle	Name-information	References
		sec.	T. S.	R. E.			
157	Sand & gravel	W 18	21	11	Anns Butte 7½'	Paulina Creek	OSHD
158	Sand & gravel	1, 6	22	10	Finley Butte 7½'	BLM pits, active, fine to med. cindery gravels	OSHD
159	Sand & gravel	SW 24	21	10	Finley Butte 7½'	Little Deschutes-outwash	OSHD
160	Sand & gravel	18	22	11	Finley Butte 7½'	Fine to med., cindery sand & gravel	OSHD
161	Cinders & scoria	20, 21	22	11	Finley Butte 7½'	Finley Butte-active pit, large supply	OSHD, USFS
162	Cinders & scoria	14	22	11	Paulina Peak 7½'	Pipeline-not active	USFS
163	Sand & gravel	NE 28	21	11	Finley Butte 7½'	Prairie-Paulina Creek outwash, good quality	USFS, OSHD
164	Quarry rock	NE 26	21	11	Paulina Peak 7½'	McKay Butte-rhyolite vitrophyre	OSHD
165	Cinder & scoria	5	22	12	Paulina Peak 7½'	Paulina Lake	USFS
166	Cinders & scoria	SE 19	20	12	Lava Cast Forest 7½'	Sugar Pine Butte	USFS
167	Cinders & scoria	SE 21	20	12	Lava Cast Forest 7½'	Lava Cast	USFS
168	Cinders & scoria	NW 24	20	12	Fuzztail Butte 7½'	Lost Buttes	USFS
169	Cinders & scoria	NE 1	21	12	Fuzztail Butte 7½'	Pilpil Butte	USFS
170	Cinders & scoria	NE 34	20	13	Fuzztail Butte 7½'	Company Butte	USFS
171	Cinders & scoria	NE 2	21	13	Fuzztail Butte 7½'	Orphan Butte	USFS
172	Cinders & scoria	SW 14	21	13	Fuzztail Butte 7½'	Cinder Hill	USFS
173	Cinders & scoria	4	22	13	No map	The Dome	USFS
174	Cinders & scoria	29	22	13	No map	Kweo Butte	USFS
175	Cinders & scoria	28	22	13	No map	Box Butte	USFS
176	Cinders & scoria	NW 25	22	13	No map	Cinder Cone	USFS
177	Cinders & scoria	SE 34	22	14	No map	Lava Pass	USFS
178	Cinders & scoria	34	21	14	No map	Sabol Butte	USFS
179	Cinders & scoria	NE 36	21	14	No map	Ground Hog Butte	USFS
180	Cinders & scoria	30	22	15	No map	Firestone Butte-active pit	USFS
181	Cinders & scoria	SE 32	22	15	No map	Rogers Butte-intermittently active	USFS
182	Cinders & scoria	SW 27	22	16	No map	Watkins Butte	USFS
183	Cinders & scoria	8, 9	22	16	No map	Plot Butte-active pit, large quantity mined	USFS
184	Quarry rock	SW 28	20	15	Pine Mt. 7½'	Pine Mt.-rhyolite	USFS
185	Cinders & scoria	11, 14	21	15	No map	Antelope Spring	USFS
186	Sand & gravel	33, 35	19	15	Millican 7½'	Layered pebbly gravels	OSHD
187	Quarry rock	SW 33	19	16	Millican SE 7½'	Small quarry, basalt lava flows	OSHD
188	Sand & gravel	4	20	16	Millican SE 7½'	Gravelly lake sediments, borrow material	OSHD
189	Sand & gravel	3	20	16	Millican SE 7½'	" " "	OSHD
190	Sand & gravel	2	20	16	Millican SE 7½'	Fine to coarse layered lake sediments, borrow pit	OSHD
191	Quarry rock	1	20	16	Millican SE 7½'	Small quarry, flow basalt	OSHD
192	Quarry rock	14	20	17	Brothers 7½'	Small quarry, flow basalt	OSHD
193	Sand & gravel	S½ 1	20	18	Brothers 7½'	Pit-run gravel, derived from John Day Formation	This study
194	Cinders & scoria	19, 20	20	19	No map	Active pit, large quantity of Grassy Butte red cinders available	OSHD
195	Sand & gravel	1	20	19	No map	-	OSHD
196	Quarry rock	NE 7	21	19	No map	Small quarry, flow basalt	OSHD
197	Sand & gravel	13	21	19	No map	-	OSHD
198	Sand & gravel	20, 21	21	20	No map	Silty gravels, fill material	OSHD
199	Sand & gravel	16	21	20	No map	Alluvial fan, silty gravels, some usable gravel	OSHD
200	Quarry rock	26	21	20	No map	Platy rhyolite, large pit	OSHD
201	Sand & gravel	15, 22	22	21	No map	Reported to be gravel & rock	OSHD
202	Cinders & scoria	28, 33	22	23	No map	Active pit	OSHD
203	Sand & gravel	14	22	23	No map	Misery Flat-pit run gravel prospect	OSHD

BULLETIN 89

GEOLOGIC COMPILATION MAP
of
DESCHUTES COUNTY
OREGON

Geology compiled by Norman V. Peterson and Edward A. Groh, 1974

Cartography by S. R. Renoud and W. H. Pokorny

1976

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
R. E. CORCORAN, STATE GEOLOGIST

INDEX TO GEOLOGIC MAPPING

- 🟩 Edward M. Taylor, 1974
- 🟫 Donald Stensland, 1974
- 🟨 Norman V. Peterson and Edward A. Groh, 1974
- 🟧 George W. Walker, Norman V. Peterson, and Robert C. Greene, 1967
- 🟥 Robert C. Greene, George W. Walker, and Raymond E. Corcoran, 1972
- 🟦 Michael W. Higgins and Aaron C. Waters, 1968

1970 MAGNETIC DECLINATION FROM TRUE NORTH VARIES FROM 19° EASTERLY FOR SOUTHEAST TIP TO 20° EASTERLY TO NORTHWESTERN BOUNDARY OF COUNTY.

Base Map from Army Map Service 1:250,000 (Topographic)

Map Sheets: Bend, 1964 and Crescent 1962

5 0 5 10 15 20 Statute Miles

5 0 5 10 15 20 25 30 Kilometers

5 0 5 10 15 Nautical Miles

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS
TRANSVERSE MERCATOR PROJECTION

EXPLANATION

Qhb Holocene basalt flows

Holocene basalt and basaltic andesite flows less than 11,000 years old. Most are dark-gray to black, dense basaltic lavas of aa or block flows. Age determined by radiocarbon, absence of Mazama pumice mantle (6,600 radiocarbon years), or estimated by comparison with other known Holocene surfaces.

Qhr Silicic flows and domes

Holocene silicic lava flows, obsidian domes, pumice cones, and ash flows. Mostly rhyolite to dacite in composition. Age determined by radiocarbon and hydration-rind dating, absence of Mazama pumice, or estimated by comparison with other known Holocene surfaces.

Qal Alluvium and surficial deposits

Unconsolidated gravels, sands, and silts laid by streams, with minor wind-deposited silt and ash. Pumiceous and cindery at many locations. Includes slope wash, playa deposits, alluvial fans, lake-bed deposits, and dune sand. Numerous patches of alluvial deposits too small to map occur on lava flows and ash flows.

Qb Pleistocene basalt flows

Gray, diktytaxitic, olivine basalts originating on and about flanks of Newberry Volcano and associated with Brothers Fault Zone in eastern part of County. Also includes large area of medium- to dark-gray, vesicular to dense olivine basalts and basaltic-andesite lavas of High Cascades, some of which are porphyritic.

Qgm Glacial and fluvio-glacial deposits

Gravels, sands, silts of glacial and fluvio-glacial origin. Includes lateral moraines, terminal moraines, drift, and outwash. Distinction between glacial and fluvio-glacial deposits and interfingering alluvium is mostly inferred. Bedrock is mapped in many places where only thinly mantled by glacial debris.

Qrd Silicic lavas and domes

Domes and flows of silicic andesite, dacite, and rhyolite mostly in Newberry Volcano area and in High Cascades, particularly in Broken Top-South Sister area.

Qwt Ash-flow deposits

A series of at least five ash-flow tuffs separated by minor erosional unconformities. Exposed mostly west of the Deschutes River; source near Broken Top volcano in High Cascades. Ash-flow units vary in color from red through gray to black and are semi-welded to highly welded. The ash-flow unit east of Newberry Caldera (Newberry Crater) is brownish, contains many rock fragments, and is believed to have been erupted from a source at Newberry Volcano.

QTb Older basalts

Thick to thin flows of vesicular to dense basalts and basaltic-andesites. Some are diktytaxitic and many dense varieties show characteristic platy jointing. Typically form rimrocks along lower Deschutes River Canyon in the northern part of County. Also a major unit in eastern part of County. Age: Pliocene and Pleistocene.

QTd Deschutes Formation

Fluviatile and lacustrine sediments composed of gravels, sands, and silts of volcanic ejecta and reworked volcanic material; much of sediment pumiceous and cindery. Interbedded basalt flows and ash-flow tuffs occur in the section; best exposed in Deschutes River Canyon in northern part of County. Diatomite deposits in Lower Bridge area of Deschutes River Canyon are included. In northern part of County, Deschutes Formation reported to be Pliocene in age but near Bend it appears to be part of a continuous depositional sequence from Pliocene into Pleistocene.

Dike Dikes

Narrow sinuous basalt spines associated with the cinder and lava mounds which in some cases mark fissure sources for the QTb flows.

QTp Pyroclastic volcanic rocks

Basaltic and andesitic scoria cones (cinder cones), mounds, and spatter cones. Composed of coarse to fine fragments varying from red to black and large to small bombs and lapilli with some agglutinate zones. Includes tuff cone Sitkum Butte, maars of North and South Twin Lakes, and eroded palagonite tuff cones of Wake Butte, also three eroded palagonite tuff cones within Newberry Caldera (Newberry crater). Includes hundreds of symmetrical cinder cones on flanks of Newberry Volcano and the east flank of the High Cascades. Many pyroclastic features modified by erosion to low mounds with intrusive spine and dike-like masses. Age: Pliocene, Pleistocene, and Holocene.

QTmv Mafic vent rocks

Constructional landforms, lava cones, and shields; some highly modified by erosion, as in High Cascades (North and Middle Sisters). Composed of basalt and basaltic-andesite flows, agglomerates, scoria, and breccia. Includes associated dikes and intrusive masses of basalt and basaltic andesite. Age: Miocene, Pliocene, and Pleistocene.

QTsv Silicic vent rocks

Domes and flow complexes of silicic andesite, dacite, and rhyolite exhibiting uneroded to highly eroded constructional forms. Age: Eocene?, Oligocene, Miocene, Pliocene, and Pleistocene.

Tb Tertiary basalt

Gray to black, mostly thin, pahoehoe, diktytaxitic basalt flows containing small to moderate amounts of olivine. Some flows are platy olivine andesite or basaltic andesite. Age: Pliocene.

Tst Tuffs and tuffaceous sedimentary rocks

Indurated to loosely consolidated lacustrine tuffaceous sandstone and siltstone. Includes also welded and non-welded tuffs, ash and ashy diatomite, claystone, conglomerate and minor fanglomerate, and tuff breccia. Restricted to eastern part of the County and may be correlative in part with Deschutes Formation. Age: Pliocene.

Twt Welded tuffs

Parts of densely welded ash-flow tuffs occurring only in the eastern part of the County. Age: Pliocene.

Tpp Pre-Pliocene rocks

Includes andesite flows and breccia of Clarno age, tuffs and tuffaceous sediments and ash-flow tuffs of John Day age, dense basalt flows of Columbia River Group, and tuffaceous sediments of probable Mascall age. Present only in several small areas along the northern boundary of County. Age: Eocene, Oligocene, and Miocene.

GEOLOGIC SYMBOLS

····— — —— Contact

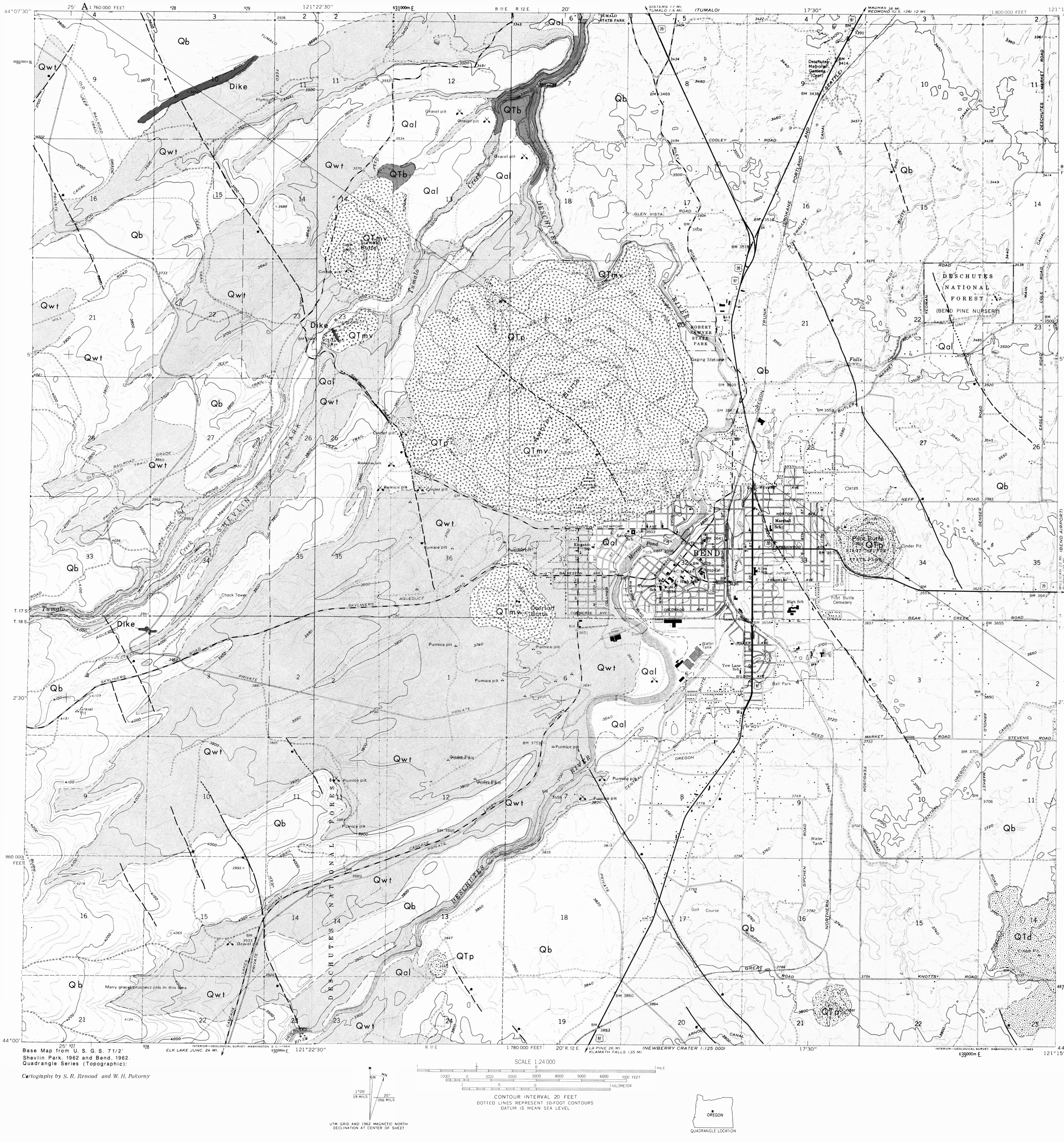
Dashed where approximately located; dotted where inferred

•••••—— Fault

Dashed where approximately located; dotted where inferred
Bar and ball on downthrown side

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
R. E. CORCORAN, STATE GEOLOGIST

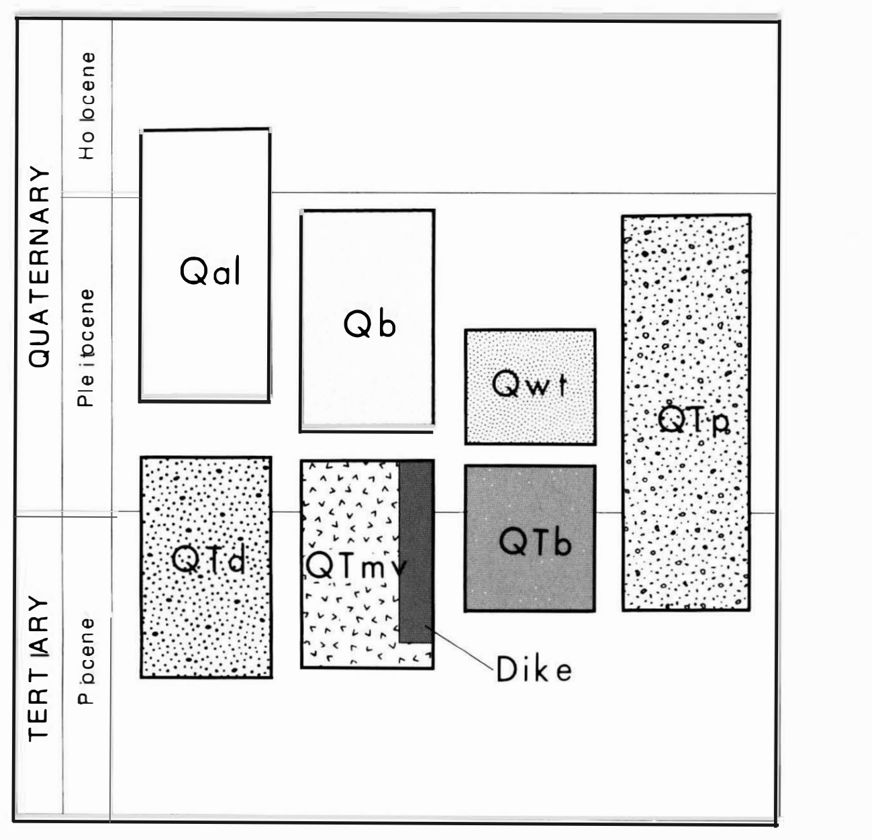
GEOLOGIC MAP
of the
BEND AREA
OREGON



Base Map from U. S. G. S. 7 1/2'
Shevlin Park, 1962 and Bend, 1962.
Quadrangle Series (Topographic):

Cartography by S. R. Renoud and W. H. Pokorny

STRATIGRAPHIC TIME CHART



EXPLANATION

Qal Alluvium and Surficial Deposits

Unconsolidated gravels, sands, and silt deposited by streams, and minor silt and ash deposited by wind. Pumiceous and cindery in many places. Numerous small patches of gravels and sand overlying Qwt not mapped. Similar small areas of silts and ash in depressions surrounded by lava flows also not mapped. Elongate to fan-shaped gravel deposits on terraces mark former channels of main drainages.

Qb Younger Basalts

Gray, diktytaxitic, olivine basalts originating on and about the northern and western flanks of Newberry Volcano. Also includes medium- to dark-gray, vesicular to dense basalt and basaltic-andesite lavas of the High Cascades, some of which are porphyritic.

Qwt Ash-flow and Air-fall Deposits

Includes a series of at least five ash-flow tuffs and a pumice fall separated by small to large erosional unconformities. Gravels and finer sediments may be found as lenses between the ash-flow units, and in places thin gravels and sands of glacial outwash origin overlie the uppermost ash-flow tuff.

QTb Older Basalts

Thick flows of mainly dark-gray, dense to vesicular basalts and basaltic-andesites. Many show characteristic platy jointing and form the rimrocks along the lower Deschutes River Canyon.

QTd Deschutes Formation

Fluviatile and lacustrine sediments composed of gravels, sand, and silts of volcanic debris. Much of the debris is pumiceous and cindery. Interbedded basalt flows and ash-flow tuffs occur in the section. Farther north the Deschutes Formation is reported to be Pliocene in age but in the Bend area there appears to be a continuous depositional sequence from Pliocene into the Pleistocene.

QTp Pyroclastic Volcanic Rocks

Basaltic scoria cones (cinder cones) and mounds consisting of red to black scoriaceous fine to coarse fragments and large to small bombs with some agglutinate. Modified in some instances by erosion to low mounds with intrusive spines and dike-like masses. Age, Pliocene and Pleistocene.

Dike
QTmv Mafic Vent Rocks

Constructional landforms, lava cones and shields, some of which are highly modified by erosion. Made up of basaltic and basaltic-andesite flows, agglomerate, scoria, and breccia. Age, Pliocene and Pleistocene. Also includes dikes of basalt and basaltic andesite.

GEOLOGIC SYMBOLS

Contacts

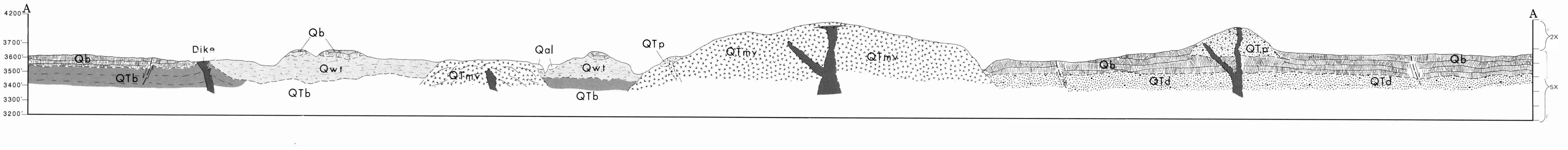
———— Definite contact
— — — — Approximate contact
– – – – – – Inferred contact
· · · · · · · · · · Concealed contact

Faults

▬▬▬▬ Definite fault, ball on downthrown side
▬▬ ▬▬ Approximate fault
▬ ▬ ▬ ▬ Inferred fault
• • • • • • • • • Concealed fault

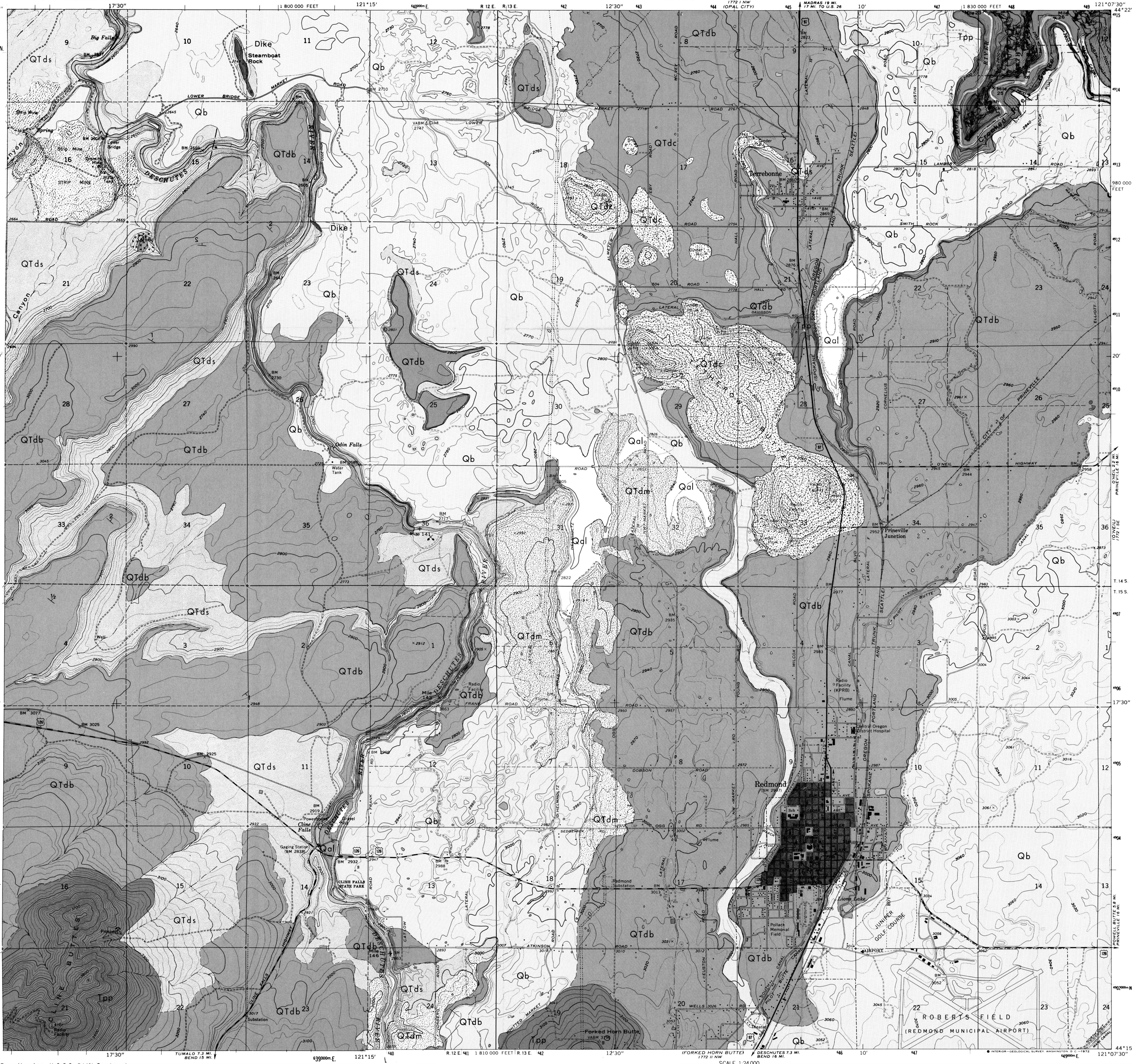
Geology by Norman V. Peterson and Edward A. Groh, 1974

Geologic Cross Section

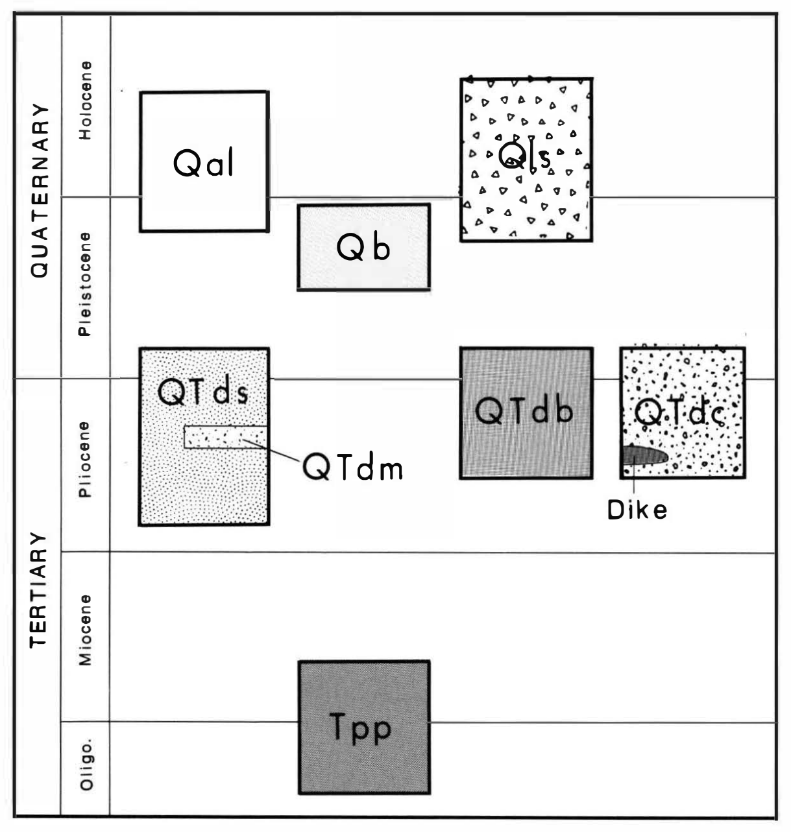


GEOLOGIC MAP
of the
REDMOND AREA
OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
R. E. CORCORAN, STATE GEOLOGIST



STRATIGRAPHIC TIME CHART



EXPLANATION

Qal Alluvium

Unconsolidated fluvial deposits of silt, sand, and gravel along streams and valley bottoms.

Qls Landslide Deposits

Slumped blocks of sediments, tuffs, and basalts along canyon walls.

Qb Basalt Flows

Intracanyon and plateau-forming pahoehoe flows of medium gray diktytaxitic olivine basalt.

Unconformity

QTds Deschutes Formation

Volcanic sediments and ash flows. Fine vitric tuffs, cindery ash and lapillic tuffs, pumice lapilli tuffs, other air-fall tuffs, and volcanic breccia, interlayered with fluvial sands, conglomerates, and breccia, some eolian sand. Also included are at least three distinctive ash-flow tuffs that range from welded to non-welded.

QTdb Basalt Flows

Mainly plateau-forming and intracanyon flows with some thin flows interbedded with QTds. Color ranges from medium to dark gray and texture from platy dense to porphyritic and diktytaxitic varieties.

QTdm Mudflow Breccia

Non-sorted, non-stratified, angular debris, predominantly cobbles, boulders, and blocks of dark-gray to black vitrophyre with large detached blocks of stratified sediments and tuffs.

QTdc Cinder and Lava Mounds

Dike

Prominent cones and low elongate mounds of cinders, scoria, and associated basalt flows and probable vents for some of the QTdb flows. Also includes dikes of basalt andbasaltic andesite.

Tpp Pre-Pliocene Rocks

Includes rocks mapped as John Day Formation at Smith Rocks and Terrebonne; other siliceous intrusive-extrusive volcanic rocks at Cline Butte and Forked Horn Butte. Composition includes silicified air-fall tuffs, flow-banded rhyolite, perlite, and andesite vitrophyre.

GEOLOGIC SYMBOLS

Contact

- ──── Definite contact
- — — — Approximate contact
- – – – – Inferred contact
- ········ Concealed contact

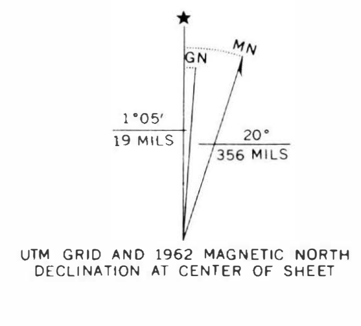
Fault

- Definite fault, ball on downthrown side
- Approximate fault
- Inferred fault
- Concealed fault
- ⊥ Strike and dip of beds

Base Map from U. S. G. S. 7 1/2' Quadrangle Series (Topographic) Maps: Redmond sheet, 1962 and Cline Falls sheet 1962.

Cartography by S. R. Renoud and W. H. Pokorny

1976



UTM GRID AND 1962 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

QUADRANGLE LOCATION

Geology modified from Donald Stensland 1974 by Norman V. Peterson and Edward A. Groh, 1975

BULLETIN 89

MINERAL LOCATION MAP
of
DESCHUTES COUNTY
OREGON

Compiled by Norman V. Peterson 1974

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
R. E. CORCORAN, STATE GEOLOGIST

LEGEND

- ⚒ Rock Quarries
- ⚔ Sand and Gravel Pits
- ⚒ Pumice, Diatomite, Clay & others
- ⚔ Cinder Pit

5 0 5 10 15 20 Statute Miles
5 0 5 10 15 20 25 30 Kilometers
5 0 5 10 15 Nautical Miles

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS
TRANSVERSE MERCATOR PROJECTION

1970 MAGNETIC DECLINATION FROM TRUE NORTH VARIES
FROM 19° EASTERLY FOR SOUTHEAST TIP TO 20°
EASTERLY TO NORTHWESTERN BOUNDARY OF COUNTY.

44°
120°30'

Base Map from Army Map Service 1:250,000 (Topographic) Map Sheets: Bend, 1964 and Crescent 1962.

Cartography by S. R. Renoud & C. A. Schumacher

Cleanup Program

Development of Oregon Background Metals Concentrations in Soil

Technical Report

March 2013

DEQ

State of Oregon
Department of Environmental Quality

Land Quality Division
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DEQ is a leader in restoring, maintaining and enhancing the quality of Oregon’s air, land and water.

This report prepared by:

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Executive Summary

The Oregon Department of Environmental Quality (DEQ) recently completed a re-evaluation of metals background data in Oregon. This presents regional background metals concentrations and provides supporting documentation on how these concentrations were developed.The background concentrations presented in this report can be used to establish background metals concentrations for cleanup sites.

The values in Table 4 of this report replace previous statewide background values contained in a 2002 DEQ memorandum (DEQ, 2002) subsequently incorporated into Appendix B of DEQ's *Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment* (DEQ, 2007) and into Table 1 of DEQ's *Human Health Risk Assessment Guidance* (DEQ, 2010). Background metals concentrations are provided for 10 physiographic provinces across the state.

Additional information on the use and application of these values is provided in DEQ's Fact Sheet titled *Background Levels of Metals in Soils for Cleanups*

1. Introduction

1.1 Purpose and Organization

The Oregon Department of Environmental Quality (DEQ) recently completed a re-evaluation of metals background data in Oregon. This project generated an Oregon-specific database representing a variety of different regions. This document's focus is to present regional background metals concentrations and provide supporting documentation on how these concentrations were developed.

A DEQ memorandum prepared in 2002 remained in draft form; however, it was commonly utilized by DEQ to help establish background metals concentrations for cleanup sites (DEQ, 2002). This memorandum presented Pacific Northwest regional default background concentrations for metals in soil and sediment. The identified soil background levels were subsequently incorporated into Appendix B of DEQ's 2007 Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment (DEQ, 2007) and into Table 1 of DEQ's 2010 Human Health Risk Assessment Guidance (DEQ, 2010).

The 2002 memorandum was itself based primarily on data obtained from the State of Washington's Department of Ecology, the United States Geological Survey (USGS), and British Columbia's Ministry of Water, Land and Air Protection. Subsequent discussions with DEQ staff indicated that there was an appreciable amount of Oregon-specific data that was not evaluated or included in this original analysis.

While DEQ's 2002 memorandum was widely used, it had the following limitations:

- The memo was based on data and literature existing in 2002. New information and datasets are now available and relevant for incorporation;
- Some data sources were not specific to Oregon, and some areas of the state were underrepresented;
- Background estimates did not account for mineralized areas like mining districts;
- Background estimates were not available for some metals considered important to risk screening;
- All of the "default" background soil values for metals from the memorandum were based on British Columbia 95th percentile or Washington 90th percentile values; and,
- Several Oregon supporting datasets were not included in the evaluation of background metals.

1.2 Funding

Funding to update information related to background metal concentrations was provided by the DEQ's "State Response" Cooperative Agreement with the Environmental Protection Agency (EPA) in 2010 and 2011. GeoEngineers, Inc., (GeoEngineers) under contract to DEQ, completed Phase 1 and Phase 2 work focused on updating DEQ's 2002 memorandum.

1.3 Acknowledgements

This document was authored by the following DEQ Environmental Cleanup Program staff and Contractors:

David Anderson, DEQ Eastern Region
Annette Dietz, DEQ Land Quality Division
Paul Seidel, DEQ Northwest Region
Neil Morton, Rob Smith, Stan Miller, of GeoEngineers, Inc.

Additional review was provided by DEQ cleanup program managers and staff.

2. Background Metals Investigation

DEQ began initial data collection efforts in 2002 and DEQ and GeoEngineers completed two phases of work beginning in 2009 to establish background metals concentrations in Oregon.

2.1 Phase 1 Work

In 2010, GeoEngineers completed Phase 1 work focused on updating DEQ's 2002 memorandum. GeoEngineers produced a Background Metals Report and associated database in June 2010 (GeoEngineers, 2010). The reporting included compilation and standardization of the analytical results into a database, including GIS information with accompanying text, summary statistics, figures, and tables (GeoEngineers, 2010).

The 2010 Background Metals Report presented state-wide and regional concentrations for 16 metals: antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc. Calculated descriptive summary statistics included minimum and maximum detected concentrations, mean, median, 25th, 75th, 90th, and 95th percentile concentrations, 90 percent upper confidence limits on the arithmetic mean (90% UCL), and box-plots for each metal dataset.

While the summary statistics presented in the 2010 report showed that the soils in Oregon differed enough from the soils of Washington and British Columbia to justify the calculation of state-specific regional background soil metals concentrations, several additional issues were identified and became the focus of Phase 2 work. The issues included:

- Detection frequency of individual metals;
- Potential outliers in the database;
- Elevated analytical detection limits;
- Areal distribution and density of sample locations; particularly the very high sample frequency in southeast Oregon; and,
- The need to update the Portland State University (PSU) and USGS datasets.

2.2 Phase 2 Work

In 2011, GeoEngineers completed the Phase 2 work which included compilation and standardization of analytical results for 5,127 samples into a database and geographic information system (GIS) with accompanying text, summary statistics, figures, and tables (GeoEngineers, 2011). The database and GIS are discussed in Section 2.3 and 2.4.

As part of Phase 2, an evaluation of the data was conducted to address outliers, non-detects, and duplicate samples. Geostatistical analysis was performed including kriging techniques to identify areas that needed additional sampling. In addition, declustering techniques[1] were implemented to reduce the number of samples in some of the areas (e.g. southeast Oregon) and ensure representativeness of the data for use in Oregon.

One of the goals of the Phase 2 work was to identify a representative dataset that could be used to calculate the background concentrations in the State of Oregon. The declustered dataset was identified as the most representative of the state and was then used to calculate descriptive summary statistics including minimum and maximum detected concentrations, mean, median, and 25th, 75th, 90th and 95th percentile concentrations. Figure 1 shows the locations of the declustered background samples. The declustered dataset was subsequently used to develop regional background concentration estimates as outlined in Section 3.

2.3 Database Sources

The 2010 Background Metals Database included analytical data from eight sources, which are briefly described below. The 2010 Background Metals Report (GeoEngineers, 2010) includes a more complete description of each data source.

- PSU Soil Database – Southwest Oregon: PSU obtained more than 400 soil samples in western Oregon to determine background metals concentrations in soil. The 2010 Background Metals Database includes 246 soil samples obtained in southwest Oregon from 118 sample locations in 1994/1995. Rafiqul Alam Khandoker's Master's thesis includes a description of the sampling methodology employed as well as an interpretation of the analytical results (Khandoker, 1997).

- PSU Soil Database – Southwest & Northwest Oregon: DEQ and GeoEngineers submitted 384 PSU soil samples, obtained in southwest and northwest Oregon in 1994/1995, for reanalysis GeoEngineers, 2010). These samples were submitted for analysis of eight metals (antimony, arsenic, beryllium, cadmium, lead, selenium, silver, and thallium) that were either not detected in 1994/1995 or had a low detection frequency.

- Mine Scarred Lands Pilot Project – Clear Creek and Ochoco Creek Basins: DEQ conducted soil, sediment, and surface water sampling in these two basins in 2006 to help establish a frame work for watershed-based assessments of mining districts in Oregon (DEQ, 2006a and 2006b). 84 soil samples from these two basins were incorporated into the 2010 Background Metals Database.

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[1] Clustered sampling often results during environmental site investigations when localized areas are over-sampled due to project-specific sampling objectives resulting in differential sampling densities when differing datasets are combined. A nearest-neighbor method for spatial declustering was used to generate a spatially unbiased dataset across the State of Oregon.

- Oregon Department of Geology and Mineral Industries (DOGAMI) – Western Ochoco National Forest: DOGAMI conducted a stream-sediment sampling program in the western part of the Ochoco National Forest in 1982 (Ferns and Brooks, 1983). The purpose of the program was to evaluate the use of geochemical sampling in helping to identify potential mineral-resource areas. The 2010 Background Metals Database includes 299 stream-sediment samples from this program.

- DOGAMI – Geoanalytical Information Layer for Oregon (GILO), Release 1: GILO is a spatial database of DOGAMI's geochemical (whole rock and trace elements) and geochronological data (Ferns and McConnell, 2005). The 2005 database contains geochemical information for 1,141 samples obtained during regional geologic mapping projects in central and eastern Oregon. 1,073 samples from this dataset were included in the 2010 Background Metals Database.

- USGS – Geochemical Datasets: The USGS has a number of geochemical datasets available on-line. The 2010 Background Metals Database includes (1) geochemistry of soils in the United States from the PLUTO database (USGS 2001) and 2) a version of the National Geochemical Survey database specific to Oregon (Smith 2007). The 2010 Background Metals Database includes 3,257 USGS soil and stream sediment samples.

- US Department of Agriculture (USDA) – National Resource Conservation Service (NRCS): The USDA – NRCS Soil Geochemistry Spatial Dataset contains data collectively produced by the National Cooperative Soil Survey (NCSS) Program (USDA-NRCS, 2009a and 2009b). The Soil Geochemistry Spatial Dataset includes two major sets of geochemistry data: 1) the NCSS Characterization Database (aka, Current Geochemistry Project) and 2) the Holmgren Dataset. The 2010 Background Metals Database includes 348 soil samples from the USDA-NRCS dataset.

- Kingsley Firing Range Annex: Shaw Environmental, Inc. obtained 18 background surface soil samples in 2007 (Shaw, 2008). These samples were submitted for chemical analysis of aluminum, antimony, arsenic, barium, copper, iron, lead, manganese, mercury, molybdenum, nickel, and zinc. The background samples were obtained at locations assumed not to be impacted by site activities and within approximately 1/2–mile of the Site.

The 2010 Background Metals Report identified two data gaps associated with the sources of soils background metals data. The 2010 Background Metals Database did not include (1) sample coordinates for the PSU soil samples obtained in northwest Oregon and did not include the 1994/1995 soil sample results for these samples and (2) the most up-to-date and comprehensive USGS geochemical dataset. One of the purposes of the Phase 2 work was to address these data gaps, as follows:

1. The 1994/1995 PSU data for northwest Oregon, and the associated sample coordinates, were incorporated into the Background Metals Database. The 1994/1995 PSU dataset for northwest Oregon contains analytical data for 8 metals (Antimony, Arsenic, Beryllium, Cadmium, Lead, Selenium, Silver, and Thallum) that were reanalyzed in 2010 using analytical methods with lower detection limits. The 1994/1995 PSU data for these eight metals are maintained in the Background Metals Database. However, because the 2010 detection limits are lower, the 2010 data and not the 1994/1995 data for these eight metals are used in the statistical analyses described in this report.

2. The latest available metals data from the USGS (National Geochemical Database) were incorporated into the Background Metals Database. The USGS data replaced older, less reliable data that generally

were based on analytical methods with higher detection limits. Specifically, the National Geochemical Database replaced two USGS datasets that were included in the June 2010 Oregon Background Metals Database (USGS: Pluto Database and USGS: NURE Database). In cases where the National Geochemical Database included multiple results for individual soil and sediment samples, results associated with analytical methods identified by USGS as having the highest analytical quality (http://tin.er.usgs.gov/geochem/method.php) were used in the statistical analyses described in this report. However, results from all available methods are included in the Background Metals Database. Multiple results are included in the National Geochemical Database because many samples were originally analyzed in the late 1970s/early 1980s using methods with inadequate detection limits. A subset of these samples was reanalyzed in later years using better analytical methods, achieving lower detection limits.

3. Background data from the Umatilla Chemical Depot (UMCD). The UMCD background dataset was sent to GeoEngineers by David Anderson (DEQ) on February 18, 2011 (Dames & Moore, 1992; Quanterra, 1998).

4. 30 additional soil samples at 15 target sampling areas collected by GeoEngineers in May 2011as part of the Phase 2 investigation. These 30 soil samples were obtained in areas within Oregon that had the greatest uncertainty associated with estimating the background value of selected metals as identified by the geostatistical and kriging analysis (GeoEngineers, 2011).

2.4 Database Development

As part of Phase 1 and Phase 2 work, GeoEngineers helped establish, standardize, and populate the Background Metals Database; specific tasks included performing the following activities:

- Converted sample locations into a common projection (geographic) and horizontal datum (WGS84) for the State of Oregon;
- Converted sample results to common units of milligrams per kilogram (mg/kg);
- Assigned each sample location to a physiographic province (see Section 2.5 below);
- Evaluated the database for overlapping samples (i.e., identify samples that are in multiple datasets);
- Flagged as non-reportable those results that were not used in the statistical evaluations;
- Selected only those analytical results from soil samples obtained between the ground surface and a depth of 3 feet in the operational database. Samples with no depth information were assumed to have been obtained between the ground surface and a depth of 3 feet; and,
- Reviewed the background dataset for each metal to identify if any non-detect (ND) values that exceeded the maximum detected concentration for those metals were included. As noted in the Background Metals Report (GeoEngineers, 2010), ND values greater than the maximum detected concentration were removed from further statistical evaluation. However, after replacing older USGS datasets with the USGS National Geochemical Database there are no longer any ND values that exceed the maximum detected concentration for the 16 background metals.

The final database consists of over 229,376 analytical results from 5,127 locationsand was developed on, and is currently stored in, Microsoft Access and ESRI ArcGIS platforms. DEQ's tables were developed from a declustered dataset of 18,456 analytical results from 1,799 locations. DEQ is evaluating options for how this database might be accessed by users in the future. Due to the size of the database, it is currently only available by request from DEQ.

2.5 Physiographic Province Development

The data were initially broken into nine physiographic provinces as defined in the Geology of Oregon (Orr et. al., 1992). The nine "regional" provinces identified in Oregon include the Coast Range, Basin and Range, Cascades, Willamette Valley, High Lava Plains, Owyhee Uplands, Blue Mountains, Klamath Mountains and Deschutes Columbia Plateau physiographic provinces (Figure 2).

The Willamette Valley province was further divided into two provinces called the South Willamette Valley and Portland Basin. The Portland Basin was identified as those northern portions of the Willamette Valley province that included Clackamas, Columbia, Multnomah, and Washington counties. In addition, some samples located in the Chehalem/Sherwood region were included in the South Willamette Valley province. The sample location points used for calculation of background concentrations in each province are shown in Figure 1. All regional data and summary statistics presented in this report are partitioned according to these boundaries.

3. Oregon Background Metals Concentrations

The background metals database was evaluated using EPA's ProUCL software (Version 4.1.00, 2009) and the R Software (Version 2.15.1, 2012) to develop Oregon background metals concentrations for the regional provinces around the state.

3.1 Statewide Data Summary

Summary statistics for the statewide declustered dataset of the 16 background metals are presented in Table 1 and include the detection frequency, range of non-detect data, range of detected concentrations, mean, standard deviation, and method used to calculate the mean and standard deviation.

3.2 Regional Data Summary

Summary statistics for the region-specific declustered dataset of the 16 background metals are presented in Table 2 and include the number of detects, number of non-detects, detection frequency, minimum detected concentration, maximum detected concentration, mean, standard deviation, and method used to calculate the mean and standard deviation.

Various statistical values calculated for the region-specific declustered dataset of the 16 background metals are presented in Table 3. These include the 90th and 95th percentile values, 90 percent upper tolerance limit (90% UTL), 90 percent upper prediction limit (90% UPL), 95% UPL and the the method used to calculate the percentiles (standard or nonparametric) for the 16 background metals.

4. Use and Application

This document's focus is to present regional background metals concentrations and provide information on how these concentrations were developed. The default background concentrations selected for use are the 95% UPL values in Table 3. The upper prediction limit was selected in consideration of the U.S. EPA recommendation to select this statistic for use in performing sample-specific comparisons to the estimated background threshold value and in consideration of its definition as a statistic that is expected to be exceeded only rarely by individual samples. A simplified table showing only these default background concentrations for each physiographic province is provided as Table 4. The boundaries of the physiographic provinces are shown in Figure 2. Additional information on the use and application of these values is provided in DEQ's Fact Sheet titled *Background Levels of Metals in Soils for Cleanups* .

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Figures

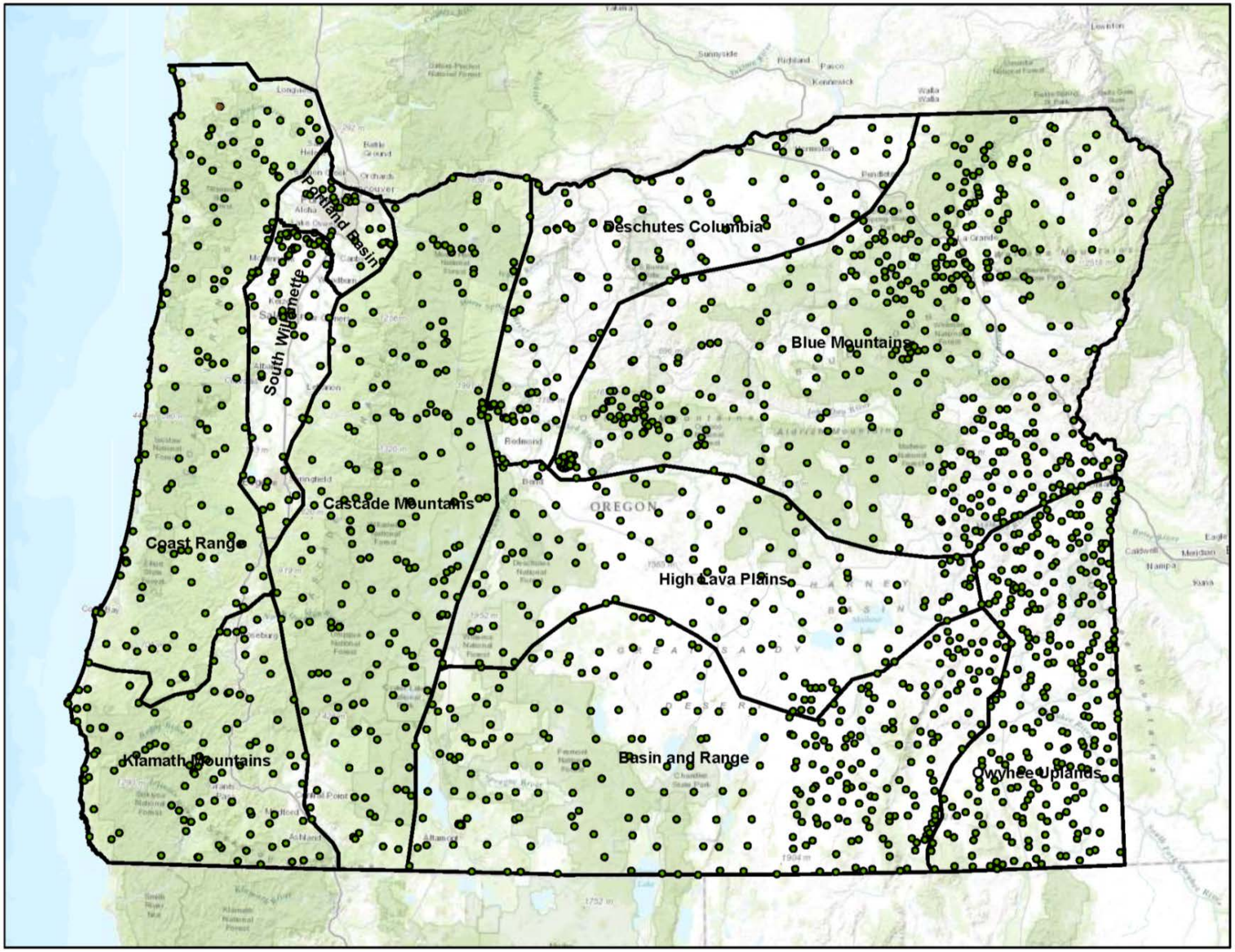

Figure 1. Background Metals Sample Locations (Declustered Dataset)

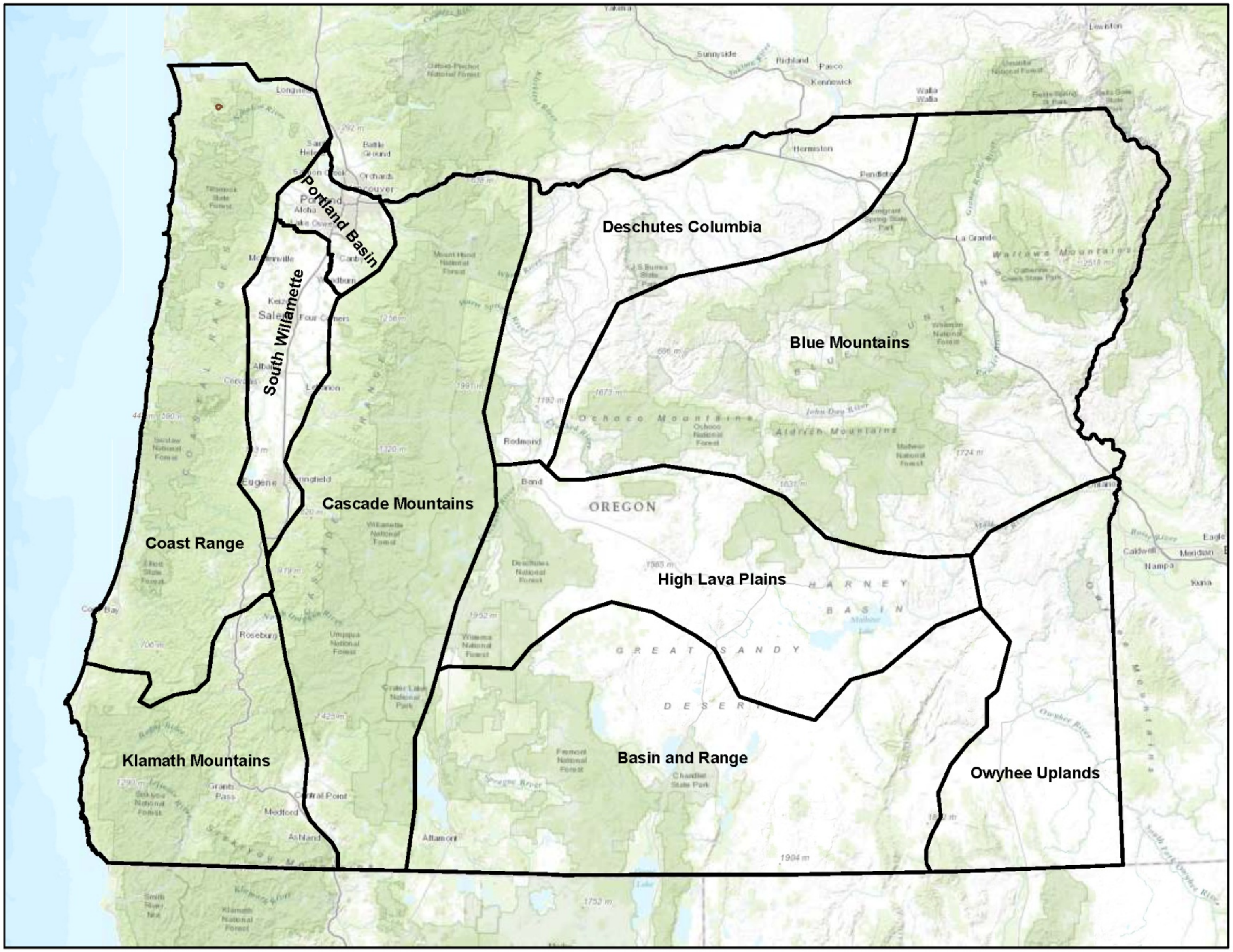

Figure 2. Physiographic Provinces of Oregon

Tables

Table 1
State-Wide Background Metals Summary Statistics
Declustered Dataset
State of Oregon

Metal	Detection Frequency		Non-Detect Range (Min - Max)	Detect Range (Min - Max)	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg							
Antimony	145/234	62%	0.0155 - 0.6	0.0204 - 1.917	0.225	0.290	Kaplan-Meier
Arsenic	1,047/1,288	81%	0.6 - 10	0.228 - 73.4	4.977	5.612	Kaplan-Meier
Barium	1,330/1,330	100%	--	10.5 - 1,855	508.70	233.60	Standard
Beryllium	1,106/1,290	86%	0.203 - 1	0.031 - 6	1.341	0.721	Kaplan-Meier
Cadmium	224/1,243	18%	0.102 - 2	0.0263 - 4.7	0.297	0.319	Kaplan-Meier
Chromium	1,331/1,331	100%	--	0.878 - 1,520	76.920	111.20	Standard
Copper	1,329/1,332	100%	2	2 - 308	38.080	29.920	Kaplan-Meier
Lead	1,282/1,328	97%	4 - 10	1 - 135	13.080	10.620	Kaplan-Meier
Manganese	1,292/1,292	100%	--	22.5 - 5,914	1015.0	557.50	Standard
Mercury	738/1,210	61%	0.02 - 0.04	0.0069 - 12.23	0.062	0.394	Kaplan-Meier
Nickel	1,320/1,322	100%	4	1 - 2,850	45.10	105.60	Kaplan-Meier
Selenium	374/1,180	32%	0.2 - 4.1	0.0613 - 5.045	0.239	0.348	Kaplan-Meier
Silver	83/1,221	7%	0.02 - 2	0.02 - 4	0.114	0.293	Kaplan-Meier
Thallium	114/208	55%	0.0568 - 4.224	0.0705 - 5.581	1.264	1.853	Kaplan-Meier
Vanadium	1,322/1,322	100%	--	4 - 486	150.30	82.320	Standard
Zinc	1,325/1,325	100%	--	11.5 - 730	93.470	41.160	Standard

Notes:
Data generated with ProUCL(Version 4.1.00), R (Version 2.15.1);

Table 2
Regional Background Metals Summary Statistics
Declustered Dataset
State of Oregon
p. 1 of 10

Metal	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg								
Basin and Range								
Antimony	19	24	44%	0.020	1.20	0.265	0.352	Kaplan-Meier
Arsenic	125	80	61%	0.588	43.0	3.990	5.033	Kaplan-Meier
Barium	204	0	100%	61.0	1200.0	561.0	179.20	Standard
Beryllium	161	46	78%	0.301	3.0	1.252	0.677	Kaplan-Meier
Cadmium	15	193	7%	0.047	4.0	0.259	0.335	Kaplan-Meier
Chromium	203	0	100%	3.50	290.0	53.540	34.230	Standard
Copper	202	0	100%	8.0	190.0	45.610	31.20	Standard
Lead	197	5	98%	1.580	68.0	14.660	8.499	Kaplan-Meier
Manganese	207	0	100%	211.0	5497.0	946.90	467.60	Standard
Mercury	90	113	44%	0.009	1.30	0.055	0.135	Kaplan-Meier
Nickel	201	0	100%	5.0	227.0	30.750	21.380	Standard
Selenium	24	150	14%	0.061	1.90	0.120	0.176	Kaplan-Meier
Silver	6	198	3%	0.059	4.0	0.101	0.305	Kaplan-Meier
Thallium	9	8	53%	0.071	0.291	0.112	0.056	Kaplan-Meier
Vanadium	200	0	100%	19.50	420.0	145.80	71.480	Standard
Zinc	203	0	100%	24.0	187.0	83.980	24.70	Standard

Table 2
Regional Background Metals Summary Statistics
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Metal	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg								
Blue Mountains								
Antimony	1	2	33%	0.143	0.143	0.143	N/A	Standard
Arsenic	208	39	84%	0.615	32.20	4.576	5.550	Kaplan-Meier
Barium	266	0	100%	34.0	1115.0	600.10	194.90	Standard
Beryllium	188	51	79%	0.031	4.0	1.315	0.785	Kaplan-Meier
Cadmium	7	231	3%	0.047	4.0	0.121	0.345	Kaplan-Meier
Chromium	259	0	100%	0.878	927.0	76.640	94.660	Standard
Copper	265	0	100%	3.0	195.50	41.410	33.670	Standard
Lead	250	17	94%	1.470	28.0	9.786	4.664	Kaplan-Meier
Manganese	244	0	100%	125.0	4797.0	1051.0	514.10	Standard
Mercury	142	105	57%	0.010	12.230	0.097	0.806	Kaplan-Meier
Nickel	264	0	100%	1.0	442.0	38.60	42.990	Standard
Selenium	78	174	31%	0.078	5.0	0.210	0.433	Kaplan-Meier
Silver	15	230	6%	0.020	3.0	0.162	0.387	Kaplan-Meier
Thallium	1	2	33%	0.149	0.149	0.149	N/A	N/A
Vanadium	259	0	100%	17.0	486.0	199.90	103.50	Standard
Zinc	266	0	100%	21.0	350.0	105.0	39.130	Standard

Table 2
Regional Background Metals Summary Statistics
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Metal	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg								
Cascade Range								
Antimony	20	31	39%	0.027	1.707	0.158	0.301	Kaplan-Meier
Arsenic	175	5	97%	0.228	73.40	5.445	7.943	Kaplan-Meier
Barium	187	0	100%	15.50	1855.0	338.10	203.50	Standard
Beryllium	153	27	85%	0.222	3.0	1.048	0.629	Kaplan-Meier
Cadmium	51	104	33%	0.048	0.969	0.261	0.169	Kaplan-Meier
Chromium	187	0	100%	3.50	394.0	66.690	63.510	Standard
Copper	188	0	100%	7.50	308.0	37.650	30.110	Standard
Lead	181	7	96%	1.0	94.550	13.390	12.490	Kaplan-Meier
Manganese	180	0	100%	48.750	4571.0	1126.0	595.0	Standard
Mercury	148	17	90%	0.020	1.230	0.068	0.101	Kaplan-Meier
Nickel	185	2	99%	2.420	243.0	44.910	39.240	Kaplan-Meier
Selenium	54	116	32%	0.095	1.20	0.215	0.184	Kaplan-Meier
Silver	13	130	9%	0.054	0.262	0.092	0.044	Kaplan-Meier
Thallium	18	33	35%	0.082	4.384	0.593	1.331	Kaplan-Meier
Vanadium	187	0	100%	15.0	400.0	145.50	78.580	Standard
Zinc	188	0	100%	17.0	477.0	98.650	48.720	Standard

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Regional Background Metals Summary Statistics
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Metal	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg								
Coast Range								
Antimony	25	7	78%	0.046	1.170	0.208	0.199	Kaplan-Meier
Arsenic	136	0	100%	0.573	16.40	5.571	3.356	Standard
Barium	140	0	100%	10.50	990.0	458.50	270.20	Standard
Beryllium	129	11	92%	0.361	4.0	1.540	0.740	Kaplan-Meier
Cadmium	36	85	30%	0.026	0.701	0.264	0.169	Kaplan-Meier
Chromium	140	0	100%	5.50	473.0	83.810	81.870	Standard
Copper	137	3	98%	2.0	202.40	36.760	40.460	Kaplan-Meier
Lead	137	3	98%	1.333	104.50	14.340	11.570	Kaplan-Meier
Manganese	133	0	100%	22.50	5115.0	914.70	648.10	Standard
Mercury	105	20	84%	0.015	0.310	0.045	0.040	Kaplan-Meier
Nickel	139	0	100%	4.0	249.0	43.230	45.680	Standard
Selenium	85	53	62%	0.153	5.045	0.457	0.616	Kaplan-Meier
Silver	14	118	11%	0.093	0.866	0.151	0.154	Kaplan-Meier
Thallium	22	10	69%	0.114	5.244	1.914	2.052	Kaplan-Meier
Vanadium	140	0	100%	6.0	329.70	122.80	72.470	Standard
Zinc	140	0	100%	11.50	413.0	88.150	47.070	Standard

Table 2
Regional Background Metals Summary Statistics

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Metal	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg								
Deschutes - Columbia Plateau								
Antimony	16	5	76%	0.093	1.917	0.403	0.480	Kaplan-Meier
Arsenic	95	0	100%	0.553	15.10	3.763	2.026	Standard
Barium	108	0	100%	103.70	967.90	498.70	168.40	Standard
Beryllium	96	0	100%	0.257	2.0	1.578	0.640	Standard
Cadmium	15	81	16%	0.128	0.587	0.243	0.094	Kaplan-Meier
Chromium	115	0	100%	3.0	306.0	49.520	50.180	Standard
Copper	115	0	100%	2.0	94.0	25.530	15.60	Standard
Lead	112	0	100%	1.0	30.0	11.050	4.922	Standard
Manganese	96	0	100%	282.50	2830.0	776.80	321.40	Standard
Mercury	31	50	38%	0.007	0.090	0.016	0.015	Kaplan-Meier
Nickel	113	0	100%	1.0	167.0	29.060	26.680	Standard
Selenium	17	79	18%	0.099	0.880	0.187	0.165	Kaplan-Meier
Silver	13	83	14%	0.099	4.0	0.163	0.395	Kaplan-Meier
Thallium	13	8	62%	0.186	4.209	1.617	1.681	Kaplan-Meier
Vanadium	116	0	100%	4.0	370.0	146.0	73.810	Standard
Zinc	108	0	100%	43.70	150.0	86.060	21.090	Standard

Table 2
Regional Background Metals Summary Statistics
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Metal	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg								
High Lava Plains								
Antimony	8	3	73%	0.109	0.393	0.172	0.093	Kaplan-Meier
Arsenic	95	10	90%	0.671	14.0	3.50	2.242	Kaplan-Meier
Barium	107	0	100%	45.0	1110.0	528.50	172.20	Standard
Beryllium	98	5	95%	0.205	3.0	1.553	0.632	Kaplan-Meier
Cadmium	12	91	12%	0.053	2.50	0.310	0.279	Kaplan-Meier
Chromium	105	0	100%	5.0	379.0	57.860	44.880	Standard
Copper	103	0	100%	11.0	95.0	33.150	14.190	Standard
Lead	103	0	100%	1.870	135.0	12.640	13.560	Standard
Manganese	104	0	100%	192.50	1910.0	873.60	307.80	Standard
Mercury	49	56	47%	0.020	0.167	0.029	0.019	Kaplan-Meier
Nickel	104	0	100%	6.0	149.0	34.070	20.0	Standard
Selenium	21	91	19%	0.070	1.90	0.184	0.216	Kaplan-Meier
Silver	5	99	5%	0.075	3.50	0.126	0.334	Kaplan-Meier
Thallium	2	9	18%	0.172	0.228	0.178	0.018	Kaplan-Meier
Vanadium	104	0	100%	26.0	275.0	123.20	53.850	Standard
Zinc	104	0	100%	24.20	214.0	92.060	29.510	Standard

Table 2
Regional Background Metals Summary Statistics
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Metal	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg								
Klamath Mountains								
Antimony	19	13	59%	0.111	0.895	0.216	0.215	Kaplan-Meier
Arsenic	94	5	95%	0.273	29.50	4.983	4.501	Kaplan-Meier
Barium	99	0	100%	14.60	1030.0	344.50	206.30	Standard
Beryllium	56	43	57%	0.063	2.0	0.622	0.465	Kaplan-Meier
Cadmium	28	70	29%	0.050	1.10	0.214	0.180	Kaplan-Meier
Chromium	99	0	100%	4.0	1520.0	236.10	296.10	Standard
Copper	99	0	100%	4.0	170.50	45.970	30.330	Standard
Lead	88	11	89%	1.360	130.0	10.920	14.760	Kaplan-Meier
Manganese	99	0	100%	45.0	3614.0	1183.0	688.40	Standard
Mercury	91	8	92%	0.020	0.280	0.080	0.052	Kaplan-Meier
Nickel	98	0	100%	5.0	2850.0	170.50	347.20	Standard
Selenium	45	46	49%	0.175	2.293	0.329	0.281	Kaplan-Meier
Silver	6	85	7%	0.104	0.265	0.112	0.029	Kaplan-Meier
Thallium	14	18	44%	0.107	0.566	0.148	0.091	Kaplan-Meier
Vanadium	99	0	100%	12.0	391.50	146.80	74.820	Standard
Zinc	99	0	100%	12.0	249.0	84.960	35.0	Standard

Table 2
Regional Background Metals Summary Statistics
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Metal	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg								
Owyhee Uplands								
Antimony	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arsenic	27	102	21%	4.50	66.0	7.315	6.120	Kaplan-Meier
Barium	124	0	100%	120.0	1300.0	764.0	153.0	Standard
Beryllium	131	0	100%	1.0	6.0	1.824	0.601	Standard
Cadmium	1	129	1%	4.0	4.0	4.0	N/A	N/A
Chromium	124	0	100%	19.0	230.0	62.810	33.020	Standard
Copper	121	0	100%	12.0	69.0	33.170	9.740	Standard
Lead	118	1	99%	4.0	88.0	15.630	8.634	Kaplan-Meier
Manganese	126	0	100%	449.70	1599.0	847.10	187.60	Standard
Mercury	28	97	22%	0.020	4.60	0.064	0.409	Kaplan-Meier
Nickel	117	0	100%	9.0	130.0	24.540	14.720	Standard
Selenium	13	51	20%	0.20	1.40	0.231	0.154	Kaplan-Meier
Silver	3	126	2%	2.0	3.0	2.016	0.124	Kaplan-Meier
Thallium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vanadium	123	0	100%	34.0	270.0	116.0	36.730	Standard
Zinc	118	0	100%	47.0	730.0	86.830	61.90	Standard

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Regional Background Metals Summary Statistics
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Metal	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg								
South Willamette Valley								
Antimony	16	4	80%	0.108	0.123	0.212	0.098	Kaplan-Meier
Arsenic	62	0	100%	1.905	58.940	9.481	8.097	Standard
Barium	65	0	100%	71.550	768.0	413.20	201.10	Standard
Beryllium	63	1	98%	0.284	3.0	1.462	0.668	Kaplan-Meier
Cadmium	38	24	61%	0.065	4.70	0.478	0.659	Kaplan-Meier
Chromium	69	0	100%	8.30	256.0	49.450	36.620	Standard
Copper	69	0	100%	5.0	194.40	40.160	38.940	Standard
Lead	66	2	97%	1.918	60.70	13.950	8.383	Kaplan-Meier
Manganese	73	0	100%	309.80	5914.0	1619.0	899.70	Standard
Mercury	45	6	88%	0.015	0.130	0.037	0.020	Kaplan-Meier
Nickel	69	0	100%	4.950	82.0	25.340	14.540	Standard
Selenium	26	27	49%	0.089	0.882	0.277	0.236	Kaplan-Meier
Silver	2	45	4%	0.101	0.710	0.126	0.122	Kaplan-Meier
Thallium	15	5	75%	0.108	4.224	2.086	2.026	Kaplan-Meier
Vanadium	64	0	100%	39.0	438.90	187.70	91.030	Standard
Zinc	69	0	100%	25.50	238.30	106.10	44.520	Standard

Table 2
Regional Background Metals Summary Statistics
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Metal	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg								
Portland Basin								
Antimony	21	0	100%	0.135	0.576	0.290	0.104	Standard
Arsenic	30	0	100%	2.40	9.495	4.447	1.847	Standard
Barium	30	0	100%	127.90	813.0	319.70	194.70	Standard
Beryllium	30	0	100%	0.386	2.0	1.013	0.541	Standard
Cadmium	21	9	70%	0.146	0.825	0.387	0.139	Kaplan-Meier
Chromium	30	0	100%	20.350	84.150	38.940	16.60	Standard
Copper	30	0	100%	11.60	60.240	24.190	9.919	Standard
Lead	30	0	100%	6.963	100.0	27.190	20.220	Standard
Manganese	30	0	100%	321.70	1979.0	1026.0	419.50	Standard
Mercury	9	0	100%	0.020	0.230	0.073	0.063	Standard
Nickel	30	0	100%	13.40	49.0	23.410	8.711	Standard
Selenium	11	19	37%	0.20	1.154	0.331	0.220	Kaplan-Meier
Silver	6	24	20%	0.106	2.169	0.179	0.370	Kaplan-Meier
Thallium	20	1	95%	4.199	5.581	4.449	0.40	Kaplan-Meier
Vanadium	30	0	100%	42.0	213.20	109.0	43.60	Standard
Zinc	30	0	100%	51.60	189.0	104.90	32.960	Standard

Notes:
Data generated with ProUCL, Version 4.1.00
N/A - Not Available

Table 3
Regional Background Calculations for Metals

Declustered Dataset
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Metal	90th Percentile	95th Percentile	Calculation Method (Percentiles)	90% UTL	90% UPL	Calculation Method	95% UPL	Calculation Method
All concentrations in mg/kg								
Basin and Range								
Antimony	0.715	0.843	Nonparametric KM(z)	0.819	0.728	90% UTL 90% Coverage;90% KM UPL (t)	**0.863**	95% KM UPL (t)
Arsenic	10.440	12.270	Nonparametric KM(z)	11.080	10.480	90% UTL 90% Coverage;90% KM UPL (t)	**12.330**	95% KM UPL (t)
Barium	740.0	783.0	Nonparametric	750.0	740.0	90% UTL 90% Coverage;90% UPL	**787.80**	95% UPL
Beryllium	2.120	2.366	Nonparametric KM(z)	2.205	2.125	90% UTL 90% Coverage;90% KM UPL (t)	**2.374**	95% KM UPL (t)
Cadmium	0.688	0.809	Nonparametric KM(z)	0.730	0.690	90% UTL 90% Coverage;90% KM UPL (t)	**0.813**	95% KM UPL (t)
Chromium	88.60	100.0	Nonparametric	96.0	89.60	90% UTL 90% Coverage;90% UPL	**100.0**	95% UPL
Copper	75.90	100.0	Nonparametric	87.0	80.90	90% UTL 90% Coverage;90% UPL	**108.50**	95% UPL
Lead	25.550	28.640	Nonparametric KM(z)	26.640	25.620	90% UTL 90% Coverage;90% KM UPL (t)	**28.740**	95% KM UPL (t)
Manganese	1304.0	1582.0	Nonparametric	1400.0	1312.0	90% UTL 90% Coverage;90% UPL	**1613.0**	95% UPL
Mercury	0.228	0.277	Nonparametric KM(z)	0.245	0.229	90% UTL 90% Coverage;90% KM UPL (t)	**0.279**	95% KM UPL (t)
Nickel	53.0	65.0	Nonparametric	54.0	53.0	90% UTL 90% Coverage;90% UPL	**65.90**	95% UPL
Selenium	0.346	0.410	Nonparametric KM(z)	0.370	0.347	90% UTL 90% Coverage;90% KM UPL (t)	**0.412**	95% KM UPL (t)
Silver	0.280	0.412	Nonparametric KM(z)	0.531	0.494	90% UTL 90% Coverage;90% KM UPL (t)	**0.417**	95% KM UPL (t)
Thallium	0.173	0.202	Nonparametric KM(z)	0.214	0.189	90% UTL 90% Coverage;90% KM UPL (t)	**0.215**	95% KM UPL (t)
Vanadium	240.0	270.0	Nonparametric	256.0	240.0	90% UTL 90% Coverage;90% UPL	**270.0**	95% UPL
Zinc	110.0	130.0	Nonparametric	120.0	110.0	90% UTL 90% Coverage;90% UPL	**130.0**	95% UPL

Table 3
Regional Background Calculations for Metals
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Metal	90th Percentile	95th Percentile	Calculation Method (Percentiles)	90% UTL	90% UPL	Calculation Method	95% UPL	Calculation Method
All concentrations in mg/kg								
Blue Mountains								
Antimony	N/A	N/A	Not enough Samples	N/A	N/A	Not enough Samples	**N/A**	Not enough Samples
Arsenic	11.690	13.70	Nonparametric KM(z)	12.320	11.720	90% UTL 90% Coverage;90% KM UPL (t)	**13.760**	95% KM UPL (t)
Barium	864.50	938.40	Nonparametric	900.0	870.0	90% UTL 90% Coverage;90% UPL	**945.30**	95% UPL
Beryllium	2.321	2.606	Nonparametric KM(z)	2.412	2.326	90% UTL 90% Coverage;90% KM UPL (t)	**2.614**	95% KM UPL (t)
Cadmium	0.563	0.689	Nonparametric KM(z)	0.603	0.565	90% UTL 90% Coverage;90% KM UPL (t)	**0.692**	95% KM UPL (t)
Chromium	140.0	183.70	Nonparametric	160.0	140.0	90% UTL 90% Coverage;90% UPL	**190.0**	95% UPL
Copper	88.20	119.60	Nonparametric	104.50	90.60	90% UTL 90% Coverage;90% UPL	**122.80**	95% UPL
Lead	15.760	17.460	Nonparametric KM(z)	16.280	15.790	90% UTL 90% Coverage;90% KM UPL (t)	**20.590**	95% KM UPL (t)
Manganese	1510.0	1732.0	Nonparametric	1590.0	1535.0	90% UTL 90% Coverage;90% UPL	**1780.0**	95% UPL
Mercury	1.130	1.423	Nonparametric KM(z)	1.222	1.135	90% UTL 90% Coverage;90% UPL	**1.430**	95% KM UPL (t)
Nickel	64.750	91.850	Nonparametric	75.50	65.750	90% UTL 90% Coverage;90% UPL	**92.0**	95% UPL
Selenium	0.765	0.922	Nonparametric KM(z)	0.814	0.767	90% UTL 90% Coverage;90% KM UPL (t)	**0.926**	95% KM UPL (t)
Silver	0.657	0.798	Nonparametric KM(z)	0.702	0.660	90% UTL 90% Coverage;90% KM UPL (t)	**0.508**	95% KM UPL (t)
Thallium	2.299	2.782	Nonparametric KM(z)	2.655	2.338	90% UTL 90% Coverage;90% KM UPL (t)	**N/A**	Not enough Samples
Vanadium	358.0	396.10	Nonparametric	378.0	358.0	90% UTL 90% Coverage;90% UPL	**397.0**	95% UPL
Zinc	146.30	155.30	Nonparametric	150.0	146.70	90% UTL 90% Coverage;90% UPL	**156.0**	95% UPL

Table 3
Regional Background Calculations for Metals
Declustered Dataset
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Metal	90th Percentile	95th Percentile	Calculation Method (Percentiles)	90% UTL	90% UPL	Calculation Method	95% UPL	Calculation Method
All concentrations in mg/kg								
Cascade Range								
Antimony	0.544	0.654	Nonparametric KM(z)	0.625	0.533	90% UTL 90% Coverage;90% KM UPL (t)	**0.668**	95% KM UPL (t)
Arsenic	15.620	18.510	Nonparametric KM(z)	16.70	15.690	90% UTL 90% Coverage;90% KM UPL (t)	**18.610**	95% KM UPL (t)
Barium	558.60	627.80	Nonparametric	590.0	564.40	90% UTL 90% Coverage;90% UPL	**632.0**	95% UPL
Beryllium	1.854	2.083	Nonparametric KM(z)	1.939	1.859	90% UTL 90% Coverage;90% KM UPL (t)	**2.091**	95% KM UPL (t)
Cadmium	0.478	0.540	Nonparametric KM(z)	0.503	0.480	90% UTL 90% Coverage;90% KM UPL (t)	**0.543**	95% KM UPL (t)
Chromium	127.60	191.40	Nonparametric	141.0	130.0	90% UTL 90% Coverage;90% UPL	**204.0**	95% UPL
Copper	59.30	69.950	Nonparametric	63.0	60.050	90% UTL 90% Coverage;90% UPL	**73.250**	95% UPL
Lead	29.40	33.940	Nonparametric KM(z)	31.050	29.50	90% UTL 90% Coverage;90% KM UPL (t)	**34.090**	95% KM UPL (t)
Manganese	1724.0	1965.0	Nonparametric	1800.0	1756.0	90% UTL 90% Coverage;90% UPL	**2111.0**	95% UPL
Mercury	0.198	0.235	Nonparametric KM(z)	0.212	0.199	90% UTL 90% Coverage;90% KM UPL (t)	**0.236**	95% KM UPL (t)
Nickel	95.210	109.50	Nonparametric KM(z)	100.40	95.520	90% UTL 90% Coverage;90% UPL	**110.0**	95% KM UPL (t)
Selenium	0.451	0.517	Nonparametric KM(z)	0.476	0.452	90% UTL 90% Coverage;90% KM UPL (t)	**0.520**	95% KM UPL (t)
Silver	0.148	0.164	Nonparametric KM(z)	0.155	0.149	90% UTL 90% Coverage;90% KM UPL (t)	**0.165**	95% KM UPL (t)
Thallium	2.299	2.782	Nonparametric KM(z)	2.655	2.338	90% UTL 90% Coverage;90% KM UPL (t)	**2.845**	95% KM UPL (t)
Vanadium	235.0	276.0	Nonparametric	251.50	236.0	90% UTL 90% Coverage;90% UPL	**280.20**	95% UPL
Zinc	144.30	166.60	Nonparametric	151.0	145.10	90% UTL 90% Coverage;90% UPL	**170.40**	95% UPL

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Regional Background Calculations for Metals
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Metal	90th Percentile	95th Percentile	Calculation Method (Percentiles)	90% UTL	90% UPL	Calculation Method	95% UPL	Calculation Method
All concentrations in mg/kg								
Coast Range								
Antimony	0.464	0.536	Nonparametric KM(z)	0.533	0.473	90% UTL 90% Coverage;90% KM UPL (t)	**0.551**	95% KM UPL (t)
Arsenic	10.260	11.670	Nonparametric	11.0	10.330	90% UTL 90% Coverage;90% UPL	**12.190**	95% UPL
Barium	804.20	834.50	Nonparametric	811.0	805.80	90% UTL 90% DEQCoverage;90% UPL	**842.60**	95% UPL
Beryllium	2.488	2.757	Nonparametric KM(z)	2.603	2.496	90% UTL 90% Coverage;90% KM UPL (t)	**2.770**	95% KM UPL (t)
Cadmium	0.480	0.541	Nonparametric KM(z)	0.508	0.482	90% UTL 90% Coverage;90% KM UPL (t)	**0.544**	95% KM UPL (t)
Chromium	159.80	222.10	Nonparametric	202.0	172.40	90% UTL 90% Coverage;90% UPL	**241.0**	95% UPL
Copper	88.610	103.30	Nonparametric KM(z)	94.870	89.050	90% UTL 90% Coverage;90% KM UPL (t)	**104.0**	95% KM UPL (t)
Lead	29.170	33.370	Nonparametric KM(z)	30.960	29.290	90% UTL 90% Coverage;90% KM UPL (t)	**33.570**	95% KM UPL (t)
Manganese	1547.0	2046.0	Nonparametric	1750.0	1574.0	90% UTL 90% Coverage;90% UPL	**2138.0**	95% UPL
Mercury	0.096	0.111	Nonparametric KM(z)	0.103	0.097	90% UTL 90% Coverage;90% KM UPL (t)	**0.112**	95% KM UPL (t)
Nickel	96.50	141.70	Nonparametric	102.0	96.50	90% UTL 90% Coverage;90% UPL	**157.0**	95% UPL
Selenium	1.246	1.470	Nonparametric KM(z)	1.342	1.253	90% UTL 90% Coverage;90% KM UPL (t)	**1.481**	95% KM UPL (t)
Silver	0.348	0.404	Nonparametric KM(z)	0.373	0.350	90% UTL 90% Coverage;90% KM UPL (t)	**0.407**	95% KM UPL (t)
Thallium	4.544	5.290	Nonparametric KM(z)	5.261	4.643	90% UTL 90% Coverage;90% KM UPL (t)	**5.448**	95% KM UPL (t)
Vanadium	239.0	254.70	Nonparametric	251.0	239.0	90% UTL 90% Coverage;90% UPL	**255.10**	95% UPL
Zinc	127.60	134.20	Nonparametric	130.0	128.0	90% UTL 90% Coverage;90% UPL	**137.80**	95% UPL

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Metal	90th Percentile	95th Percentile	Calculation Method (Percentiles)	90% UTL	90% UPL	Calculation Method	95% UPL	Calculation Method
All concentrations in mg/kg								
Deschutes - Columbia Plateau								
Antimony	1.018	1.193	Nonparametric KM(z)	1.243	1.054	90% UTL 90% Coverage;90% KM UPL (t)	**1.250**	95% KM UPL (t)
Arsenic	5.540	6.129	Nonparametric	5.80	5.608	90% UTL 90% Coverage;90% UPL	**6.824**	95% UPL
Barium	657.80	694.0	Nonparametric	668.0	662.50	90% UTL 90% Coverage;90% UPL	**704.60**	95% UPL
Beryllium	2.363	2.593	Nonparametric KM(z)	2.0	2.0	90% UTL 90% Coverage;90% UPL	**2.608**	95% KM UPL (t)
Cadmium	0.364	0.398	Nonparametric KM(z)	0.381	0.365	90% UTL 90% Coverage;90% KM UPL (t)	**0.40**	95% KM UPL (t)
Chromium	81.40	142.90	Nonparametric	99.0	82.80	90% UTL 90% Coverage;90% UPL	**169.80**	95% UPL
Copper	50.360	58.30	Nonparametric	56.0	51.160	90% UTL 90% Coverage;90% UPL	**29.40**	95% UPL
Lead	15.0	17.450	Nonparametric	16.0	15.350	90% UTL 90% Coverage;90% UPL	**18.350**	95% UPL
Manganese	1032.0	1291.0	Nonparametric	1140.0	1058.0	90% UTL 90% Coverage;90% UPL	**1323.0**	95% UPL
Mercury	0.035	0.040	Nonparametric KM(z)	0.038	0.035	90% UTL 90% Coverage;90% KM UPL (t)	**0.040**	95% KM UPL (t)
Nickel	45.70	83.70	Nonparametric	62.0	55.0	90% UTL 90% Coverage;90% UPL	**78.440**	95% UPL
Selenium	0.398	0.458	Nonparametric KM(z)	0.429	0.40	90% UTL 90% Coverage;90% KM UPL (t)	**0.462**	95% KM UPL (t)
Silver	0.668	0.811	Nonparametric KM(z)	0.743	0.674	90% UTL 90% Coverage;90% KM UPL (t)	**0.821**	95% KM UPL (t)
Thallium	3.771	4.381	Nonparametric KM(z)	4.558	3.897	90% UTL 90% Coverage;90% KM UPL (t)	**4.584**	95% KM UPL (t)
Vanadium	240.30	284.0	Nonparametric	262.0	241.70	90% UTL 90% Coverage;90% UPL	**299.30**	95% UPL
Zinc	112.30	124.30	Nonparametric	120.0	113.20	90% UTL 90% Coverage;90% UPL	**127.20**	95% UPL

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Regional Background Calculations for Metals
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Metal	**90th Percentile**	**95th Percentile**	**Calculation Method (Percentiles)**	**90% UTL**	**90% UPL**	**Calculation Method**	**95% UPL**	**Calculation Method**
All concentrations in mg/kg								
High Lava Plains								
Antimony	0.291	0.325	Nonparametric KM(z)	0.359	0.305	90% UTL 90% Coverage;90% KM UPL (t)	**0.348**	95% KM UPL (t)
Arsenic	6.373	7.188	Nonparametric KM(z)	6.777	6.405	90% UTL 90% Coverage;90% KM UPL (t)	**7.238**	95% KM UPL (t)
Barium	671.10	778.20	Nonparametric	712.0	687.20	90% UTL 90% Coverage;90% UPL	**790.20**	95% UPL
Beryllium	2.363	2.593	Nonparametric KM(z)	2.479	2.373	90% UTL 90% Coverage;90% KM UPL (t)	**2.608**	95% KM UPL (t)
Cadmium	0.667	0.769	Nonparametric KM(z)	0.718	0.671	90% UTL 90% Coverage;90% KM UPL (t)	**0.775**	95% KM UPL (t)
Chromium	93.40	117.20	Nonparametric	102.0	96.20	90% UTL 90% Coverage;90% UPL	**141.70**	95% UPL
Copper	47.0	57.150	Nonparametric	51.0	48.20	90% UTL 90% Coverage;90% UPL	**62.30**	95% UPL
Lead	15.0	18.80	Nonparametric	16.0	15.60	90% UTL 90% Coverage;90% UPL	**21.40**	95% UPL
Manganese	1284.0	1429.0	Nonparametric	1399.0	1310.0	90% UTL 90% Coverage;90% UPL	**1482.0**	95% UPL
Mercury	0.053	0.060	Nonparametric KM(z)	0.056	0.053	90% UTL 90% Coverage;90% KM UPL (t)	**0.060**	95% KM UPL (t)
Nickel	53.250	70.650	Nonparametric	56.0	54.50	90% UTL 90% Coverage;90% UPL	**75.380**	95% UPL
Selenium	0.461	0.540	Nonparametric KM(z)	0.499	0.464	90% UTL 90% Coverage;90% KM UPL (t)	**0.544**	95% KM UPL (t)
Silver	0.553	0.675	Nonparametric KM(z)	0.614	0.558	90% UTL 90% Coverage;90% KM UPL (t)	**0.682**	95% KM UPL (t)
Thallium	0.201	0.207	Nonparametric KM(z)	0.214	0.203	90% UTL 90% Coverage;90% KM UPL (t)	**0.212**	95% KM UPL (t)
Vanadium	201.60	219.60	Nonparametric	215.0	208.50	90% UTL 90% Coverage;90% UPL	**223.80**	95% UPL
Zinc	121.90	136.90	Nonparametric	129.0	122.0	90% UTL 90% Coverage;90% UPL	**139.30**	95% UPL

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Regional Background Calculations for Metals
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Metal	90th Percentile	95th Percentile	Calculation Method (Percentiles)	90% UTL	90% UPL	Calculation Method	95% UPL	Calculation Method
All concentrations in mg/kg								
Klamath Mountains								
Antimony	0.492	0.570	Nonparametric KM(z)	0.567	0.502	90% UTL 90% Coverage;90% KM UPL (t)	**0.587**	95% KM UPL (t)
Arsenic	10.750	12.390	Nonparametric KM(z)	11.590	10.820	90% UTL 90% Coverage;90% KM UPL (t)	**12.490**	95% KM UPL (t)
Barium	568.80	630.20	Nonparametric	607.0	572.0	90% UTL 90% Coverage;90% UPL	**632.0**	95% UPL
Beryllium	1.217	1.386	Nonparametric KM(z)	1.304	1.224	90% UTL 90% Coverage;90% KM UPL (t)	**1.397**	95% KM UPL (t)
Cadmium	0.445	0.510	Nonparametric KM(z)	0.479	0.448	90% UTL 90% Coverage;90% KM UPL (t)	**0.515**	95% KM UPL (t)
Chromium	624.20	762.60	Nonparametric	668.0	625.0	90% UTL 90% Coverage;90% UPL	**894.0**	95% UPL
Copper	77.0	100.90	Nonparametric	89.50	79.0	90% UTL 90% Coverage;90% UPL	**108.50**	95% UPL
Lead	29.840	35.20	Nonparametric KM(z)	32.590	30.060	90% UTL 90% Coverage;90% KM UPL (t)	**35.560**	95% KM UPL (t)
Manganese	1830.0	2948.0	Nonparametric	2113.0	1870.0	90% UTL 90% Coverage;90% UPL	**2957.0**	95% UPL
Mercury	0.146	0.165	Nonparametric KM(z)	0.156	0.147	90% UTL 90% Coverage;90% KM UPL (t)	**0.166**	95% KM UPL (t)
Nickel	343.0	472.60	Nonparametric	396.0	360.60	90% UTL 90% Coverage;90% UPL	**634.40**	95% UPL
Selenium	0.689	0.791	Nonparametric KM(z)	0.744	0.694	90% UTL 90% Coverage;90% KM UPL (t)	**0.799**	95% KM UPL (t)
Silver	0.148	0.159	Nonparametric KM(z)	0.154	0.149	90% UTL 90% Coverage;90% KM UPL (t)	**0.159**	95% KM UPL (t)
Thallium	0.264	0.298	Nonparametric	0.296	0.269	90% UTL 90% Coverage;90% KM UPL (t)	**0.305**	95% KM UPL (t)
Vanadium	237.20	277.0	Nonparametric	253.0	238.0	90% UTL 90% Coverage;90% UPL	**286.0**	95% UPL
Zinc	120.0	135.90	Nonparametric	122.0	120.0	90% UTL 90% Coverage;90% UPL	**139.0**	95% UPL

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Regional Background Calculations for Metals
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Metal	**90th Percentile**	**95th Percentile**	**Calculation Method (Percentiles)**	**90% UTL**	**90% UPL**	**Calculation Method**	**95% UPL**	**Calculation Method**
All concentrations in mg/kg								
Owyhee Uplands								
Antimony	N/A	N/A	No Data	N/A	N/A	No Data	**N/A**	No Data
Arsenic	15.160	17.380	Nonparametric KM(z)	16.150	15.230	90% UTL 90% Coverage;90% KM UPL (t)	**17.490**	95% KM UPL (t)
Barium	907.0	950.0	Nonparametric	930.0	915.0	90% UTL 90% Coverage;90% UPL	**965.0**	95% UPL
Beryllium	2.0	2.0	Nonparametric	2.0	2.0	90% UTL 90% Coverage;90% UPL	**2.0**	95% UPL
Cadmium	N/A	N/A	Not enough Samples	N/A	N/A	Not enough Samples	**N/A**	Not enough Samples
Chromium	91.10	117.70	Nonparametric	104.0	94.50	90% UTL 90% Coverage;90% UPL	**119.80**	95% UPL
Copper	45.0	50.0	Nonparametric	48.0	45.80	90% UTL 90% Coverage;90% UPL	**50.0**	95% UPL
Lead	26.70	29.830	Nonparametric KM(z)	28.150	26.80	90% UTL 90% Coverage;90% KM UPL (t)	**30.0**	95% KM UPL (t)
Manganese	1099.0	1199.0	Nonparametric	1099.0	1099.0	90% UTL 90% Coverage;90% UPL	**1199.0**	95% UPL
Mercury	0.588	0.737	Nonparametric KM(z)	0.655	0.593	90% UTL 90% Coverage;90% KM UPL (t)	**0.745**	95% KM UPL (t)
Nickel	33.40	50.40	Nonparametric	41.0	34.60	90% UTL 90% Coverage;90% UPL	**52.60**	95% UPL
Selenium	0.429	0.485	Nonparametric KM(z)	0.465	0.432	90% UTL 90% Coverage;90% KM UPL (t)	**0.490**	95% KM UPL (t)
Silver	2.174	2.219	Nonparametric KM(z)	2.194	2.175	90% UTL 90% Coverage;90% KM UPL (t)	**2.221**	95% KM UPL (t)
Thallium	N/A	N/A	No Data	N/A	N/A	No Data	**N/A**	No Data
Vanadium	160.0	189.0	Nonparametric	170.0	160.0	90% UTL 90% Coverage;90% UPL	**190.0**	95% UPL
Zinc	100.0	120.0	Nonparametric	110.0	100.0	90% UTL 90% Coverage;90% UPL	**120.50**	95% UPL

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Regional Background Calculations for Metals
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Metal	90th Percentile	95th Percentile	Calculation Method (Percentiles)	90% UTL	90% UPL	Calculation Method	95% UPL	Calculation Method
All concentrations in mg/kg								
South Willamette Valley								
Antimony	0.337	0.372	Nonparametric KM(z)	0.384	0.345	90% UTL 90% Coverage;90% KM UPL (t)	**0.385**	95% KM UPL (t)
Arsenic	16.780	17.50	Nonparametric	17.40	17.180	90% UTL 90% Coverage;90% UPL	**17.650**	95% UPL
Barium	682.40	708.90	Nonparametric	688.50	683.60	90% UTL 90% Coverage;90% UPL	**734.30**	95% UPL
Beryllium	2.319	2.562	Nonparametric KM(z)	2.477	2.335	90% UTL 90% Coverage;90% KM UPL (t)	**2.587**	95% KM UPL (t)
Cadmium	1.323	1.563	Nonparametric KM(z)	1.481	1.339	90% UTL 90% Coverage;90% KM UPL (t)	**1.588**	95% KM UPL (t)
Chromium	82.0	94.60	Nonparametric	91.0	82.0	90% UTL 90% Coverage;90% UPL	**103.30**	95% UPL
Copper	74.20	124.50	Nonparametric	105.0	79.0	90% UTL 90% Coverage;90% UPL	**141.30**	95% UPL
Lead	24.690	27.740	Nonparametric KM(z)	26.60	24.880	90% UTL 90% Coverage;90% KM UPL (t)	**28.030**	95% KM UPL (t)
Manganese	2434.0	2845.0	Nonparametric	2540.0	2439.0	90% UTL 90% Coverage;90% UPL	**2936.0**	95% UPL
Mercury	0.064	0.071	Nonparametric KM(z)	0.069	0.064	90% UTL 90% Coverage;90% KM UPL (t)	**0.072**	95% KM UPL (t)
Nickel	44.60	49.050	Nonparametric	48.890	47.0	90% UTL 90% Coverage;90% UPL	**50.080**	95% UPL
Selenium	0.579	0.665	Nonparametric KM(z)	0.641	0.586	90% UTL 90% Coverage;90% KM UPL (t)	**0.675**	95% KM UPL (t)
Silver	0.282	0.326	Nonparametric KM(z)	0.316	0.286	90% UTL 90% Coverage;90% KM UPL (t)	**0.333**	95% KM UPL (t)
Thallium	4.683	5.419	Nonparametric KM(z)	5.662	4.843	90% UTL 90% Coverage;90% KM UPL (t)	**5.676**	95% KM UPL (t)
Vanadium	323.90	366.0	Nonparametric	368.80	370.80	90% UTL 90% Coverage;90% UPL	**370.80**	95% UPL
Zinc	167.0	187.90	Nonparametric	195.50	200.30	90% UTL 90% Coverage;90% UPL	**200.30**	95% UPL

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Regional Background Calculations for Metals
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Metal	90th Percentile	95th Percentile	Calculation Method (Percentiles)	90% UTL	90% UPL	Calculation Method	95% UPL	Calculation Method
All concentrations in mg/kg								
Portland Basin								
Antimony	0.381	0.385	Nonparametric	0.385	0.384	90% UTL 90% Coverage;90% UPL	**0.557**	95% UPL
Arsenic	6.728	8.062	Nonparametric	8.215	7.748	90% UTL 90% Coverage;90% UPL	**8.791**	95% UPL
Barium	704.90	754.70	Nonparametric	774.0	728.10	90% UTL 90% Coverage;90% UPL	**791.60**	95% UPL
Beryllium	2.0	2.0	Nonparametric	2.0	2.0	90% UTL 90% Coverage;90% UPL	**2.0**	95% UPL
Cadmium	0.565	0.616	Nonparametric KM(z)	0.618	0.572	90% UTL 90% Coverage;90% KM UPL (t)	**0.627**	95% KM UPL (t)
Chromium	63.050	66.50	Nonparametric	68.950	63.450	90% UTL 90% Coverage;90% UPL	**75.790**	95% UPL
Copper	31.810	32.990	Nonparametric	33.550	32.250	90% UTL 90% Coverage;90% UPL	**33.750**	95% UPL
Lead	56.220	59.650	Nonparametric	61.930	56.780	90% UTL 90% Coverage;90% UPL	**79.060**	95% UPL
Manganese	1383.0	1504.0	Nonparametric	1584.0	1402.0	90% UTL 90% Coverage;90% UPL	**1762.0**	95% UPL
Mercury	0.174	0.202	Nonparametric	0.230	0.230	90% UTL 90% Coverage;90% UPL	**0.230**	95% UPL
Nickel	34.40	44.430	Nonparametric	46.0	41.60	90% UTL 90% Coverage;90% UPL	**47.350**	95% UPL
Selenium	0.612	0.692	Nonparametric KM(z)	0.695	0.624	90% UTL 90% Coverage;90% KM UPL (t)	**0.710**	95% KM UPL (t)
Silver	0.653	0.788	Nonparametric KM(z)	0.792	0.672	90% UTL 90% Coverage;90% KM UPL (t)	**0.818**	95% KM UPL (t)
Thallium	4.962	5.107	Nonparametric KM(z)	5.149	4.992	90% UTL 90% Coverage;90% KM UPL (t)	**5.156**	95% KM UPL (t)
Vanadium	165.70	173.70	Nonparametric	175.10	171.30	90% UTL 90% Coverage;90% UPL	**178.20**	95% UPL
Zinc	124.10	154.10	Nonparametric	178.0	124.90	90% UTL 90% Coverage;90% UPL	**182.90**	95% UPL

Notes:
Data generated with ProUCL (Version 4.1.00), R (Version 2.15.1)
UTL = Upper threshold limit
UPL = Upper prediction limit
KM = Kaplan-Meier

Table 4
Regional 95% UPL Default Background Concentrations for Metals in Soil
State of Oregon

All concentrations in mg/kg

Metal	Basin and Range		Blue Mountains		Cascade Range		Coast Range		Deschutes - Columbia Plateau		High Lava Plains		Klamath Mountains		Owyhee Uplands		South Willamette Valley		Portland Basin	
Antimony	0.86	(a)	N/A	(c)	0.67	(a)	0.55	(a)	1.3	(a)	0.35	(a)	0.59	(a)	N/A	(d)	0.39	(a)	0.56	(b)
Arsenic	12	(a)	14	(a)	19	(a)	12	(b)	6.8	(b)	7.2	(a)	12	(a)	17	(a)	18	(b)	8.8	(b)
Barium	790	(b)	950	(b)	630	(b)	840	(b)	700	(b)	790	(b)	630	(b)	970	(b)	730	(b)	790	(b)
Beryllium	2.4	(a)	2.6	(a)	2.1	(a)	2.8	(a)	2.6	(a)	2.6	(a)	1.4	(a)	2.0	(b)	2.6	(a)	2.0	(b)
Cadmium	0.81	(a)	0.69	(a)	0.54	(a)	0.54	(a)	0.40	(a)	0.78	(a)	0.52	(a)	N/A	(c)	1.6	(a)	0.63	(a)
Chromium	100	(b)	190	(b)	200	(b)	240	(b)	170	(b)	140	(b)	890	(b)	120	(b)	100	(b)	76	(b)
Copper	110	(b)	120	(b)	73	(b)	100	(a)	29	(b)	62	(b)	110	(b)	50	(b)	140	(b)	34	(b)
Lead	29	(a)	21	(a)	34	(a)	34	(a)	18	(b)	21	(b)	36	(a)	30	(a)	28	(a)	79	(b)
Manganese	1600	(b)	1800	(b)	2100	(b)	2100	(b)	1300	(b)	1500	(b)	3000	(b)	1200	(b)	2900	(b)	1800	(b)
Mercury	0.28	(a)	1.4	(a)	0.24	(a)	0.11	(a)	0.040	(a)	0.060	(a)	0.17	(a)	0.75	(a)	0.070	(a)	0.23	(b)
Nickel	66	(b)	92	(b)	110	(a)	160	(b)	78	(b)	75	(b)	630	(b)	53	(b)	50	(b)	47	(b)
Selenium	0.41	(a)	0.93	(a)	0.52	(a)	1.5	(a)	0.46	(a)	0.54	(a)	0.80	(a)	0.49	(a)	0.68	(a)	0.71	(a)
Silver	0.42	(a)	0.51	(a)	0.17	(a)	0.41	(a)	0.82	(a)	0.68	(a)	0.16	(a)	2.2	(a)	0.33	(a)	0.82	(a)
Thallium	0.22	(a)	N/A	(c)	2.8	(a)	5.4	(a)	4.6	(a)	0.21	(a)	0.31	(a)	N/A	(d)	5.7	(a)	5.2	(a)
Vanadium	270	(b)	400	(b)	280	(b)	260	(b)	300	(b)	220	(b)	290	(b)	190	(b)	370	(b)	180	(b)
Zinc	130	(b)	160	(b)	170	(b)	140	(b)	130	(b)	140	(b)	140	(b)	120	(b)	200	(b)	180	(b)

Notes:
Data generated with ProUCL, Version 4.1.00
UPL = Upper prediction limit
(a) = 95% Kaplan-Meier UPL (t)
(b) = 95% UPL
(c) = Not Enough Samples
(d) = No Data

Series 1945, No. 2

Issued December 1958

SOIL SURVEY

Deschutes Area
Oregon

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In Cooperation with
OREGON AGRICULTURAL EXPERIMENT STATION

How to Use THE SOIL SURVEY REPORT

THIS SURVEY of the Deschutes Area will help you plan the kind of farming that will protect your soils and provide good yields. It describes the soils, shows their location on a map, and tells what they will do under different kinds of management.

Find Your Farm on the Map

In using this survey, start with the soil map, which consists of the 45 sheets bound in the back of this report. These sheets, if laid together, make a large map of the county. The map shows township and section lines, towns and villages, roads, streams, most of the houses in rural areas, and other landmarks.

To find your farm on the large map, use the index to map sheets. This is a small map of the Area on which numbered rectangles have been drawn to show where each sheet of the large map is located.

When you have found the map sheet for your farm, you will notice that boundaries of the soils have been outlined and that there is a symbol for each kind of soil. All areas marked with the same symbol are the same kind of soil, wherever they appear on the map.

Suppose you have found on your farm an area marked with the symbol De. You learn the name of the soil this symbol represents by looking at the map legend. The symbol De identifies Deschutes loamy sand, 0 to 3 percent slopes.

Learn About the Soils on Your Farm

Deschutes loamy sand, 0 to 3 percent slopes, and all the other soils mapped are described in the section, Soil Types and Phases. Soil scientists, as they walked over the fields, described and mapped the soils. They dug holes and examined surface soils and subsoils; measured slopes with a hand level; noted differences in growth of crops, weeds, brush, or trees; and, in fact, recorded all the things about the soils that they believed might affect their suitability for farming.

After they mapped and studied the soils, the scientists placed them in management groups and subgroups and in capability groups. A management subgroup is a group of similar soils that need and respond to about the same kind of management. A capability group shows the uses that can be made of the soil and the kind of management needed to protect the soil and to obtain useful crops and other plants.

Deschutes loamy sand, 0 to 3 percent slopes, is in management subgroup 1B. Turn to the section, Use and Management of Soils, and read what is said about soils of subgroup 1B. You will want to study table 3, which tells you how much you can expect to harvest from Deschutes loamy sand, 0 to 3 percent slopes.

Make a Farm Plan

For the soils on your farm, compare your yields and farm practices with those given in this report. Look at your fields for signs of runoff and erosion. Then decide whether or not you need to change your methods. The choice, of course, must be yours. This survey will aid you in planning new methods, but it is not a plan of management for your farm or any other farm in the county.

If you find that you need help in farm planning, consult the local representative of the Soil Conservation Service or the county agricultural agent. Members of the staff of your State agricultural experiment station and others familiar with farming in your county will also be glad to help you.

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Washington 25, D. C.

Contents

Soils of the Deschutes Area—Continued
  Soil types and phases—Continued
    Lamonta loam—Continued

Soils of the Deschutes Area—Continued
  Soil types and phases—Continued
    Madras sandy loam—Continued

Use and management of soils—Continued

Management group 2—Continued

Agriculture—Continued

Issued December 1958

SOIL SURVEY OF THE DESCHUTES AREA, OREGON

REPORT BY W. J. LEIGHTY, SOIL SCIENTIST, SOIL SURVEY,[1] UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL SURVEYED BY E. F. TORGERSON AND J. M. WILLIAMS, OREGON AGRICULTURAL EXPERIMENT STATION; AND M. F. SANDOZ, W. P. BADURINA, T. W. BENDIXEN, D. H. DALY, M. E. DENNY, T. W. GLASSEY, AND R. A. SALZMANN, UNITED STATES DEPARTMENT OF AGRICULTURE

CORRELATION BY A. E. KOCHER AND W. J. LEIGHTY, UNITED STATES DEPARTMENT OF AGRICULTURE

The Deschutes Area

The Deschutes Area occupies 526.2 square miles in west-central Oregon along the Deschutes River (fig. 1). About half of the Area is in Deschutes County and half in Jefferson County. The climate is semiarid. Much of the Area has been used for range grazing and dry farming, but today large districts are irrigated and the acreage used for dry farming has decreased. The Area contains about three-fourths of the cropland of Deschutes County and Jefferson County. Farming is the most important enterprise. The main crops are potatoes, wheat and other grain, and alfalfa, and clover grown for seed. Livestock is raised for meat and for dairy products. The lumber industry is important in the southern part of the Area.

This is a cooperative soil survey made by the Department of Agriculture and the Oregon Agricultural Experiment Station. It was made to aid the farmers in planning the best use of their soils. It is not intended as a substitute for the detailed information on management and crop varieties that can be obtained from county agricultural agents, local representatives of the Soil Conservation Service, the State experiment stations, or similar sources.

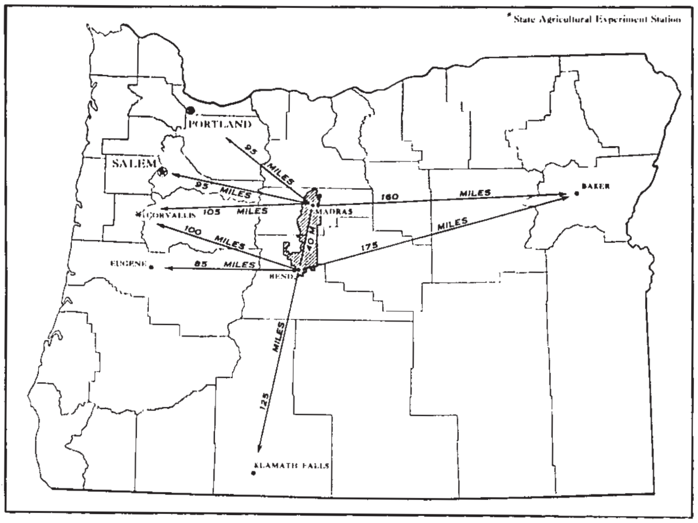

Figure 1.—**Location of the Deschutes Area in Oregon.**

The fieldwork for this survey was completed in 1945. Unless otherwise indicated, all statements in this report refer to conditions in the Area at that time.

Soils of the Deschutes Area

The soils of the Deschutes Area generally are similar to other soils of the semiarid region of central Oregon. This similarity is greatest in those characteristics that were determined mainly by the effects of climate and vegetation. Table 1 gives some important characteristics of the soil series of the Area.

In the extreme southern and southwestern parts of the Area, the climate is similar to that where rather luxuriant grasses grow in parts of Umatilla County, the Palouse region in Washington, and in many places in a belt below the forests of the Blue Mountains. But in the extreme southern and southwestern parts of the Area, the vegetation is sparse, apparently because the coarse texture of the soil material is not suited to a dense growth of grasses. The upper part of these soils is sandy; it developed from a geologically young mantle of pumice. These soils are light colored and low in organic matter and nitrogen. The soils on which the grasses are more dense are darker colored and contain more organic matter.

On and near Haystack Butte and Juniper Butte, the altitude and precipitation generally are higher than in most of the Area, and the parent material is finer. Grasses and other plants are more dense. The upper part of the soil is moderately dark in color and contains a moderate to somewhat high organic-matter and nitrogen content.

The soils of the Area are not so highly leached as the soils in regions of high precipitation. Most of the soils contain a moderate to large amount of plant nutrients, but on some of the soils applications of sulfur, potash, phosphate, boron, and nitrogen are needed for certain crops. Most of the soils of the Area need no lime.

Most of the soils of the Area are sandy loams, but the texture ranges from loamy coarse sand to clay loam. Generally the coarse-textured soils are easier to work and more permeable than the medium-textured or fine-

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[1] Fieldwork for this survey was done under the direction of the Division of Soil Survey when it was a part of the Bureau of Plant Industry, Soils, and Agricultural Engineering. Soil Survey was transferred to the Soil Conservation Service on November 15, 1952.

TABLE 1.—*Important characteristics of the soil series*

Soil series	Topographic position	Drainage	Subsoil	Parent material
Agency	Nearly level to hilly uplands.	Good	Clay loam; calcareous in lower part.	In upper part, weathered pumiceous or tuffaceous sandstone and agglomerate and a little fine wind-carried material; weathered basaltic or other lava material in lower part.
Deschutes	Same	Good to somewhat excessive.	Sandy loam or loamy sand; calcareous in lower part.	Wind-carried pumice sand.
Era	Same	Good	Sandy loam or loam; calcareous in lower part.	In upper part, weathered pumiceous or tuffaceous sandstone and agglomerate and a little fine wind-carried material; weathered basaltic or other lava material in lower part.
Gem	Undulating to hilly uplands.	Good	Clay; calcareous in lower part.	Weathered basalt.
Laidlaw	Nearly level to hilly uplands.	Good to somewhat excessive.	Sandy loam; noncalcareous.	Wind-carried pumice over pumice flow.
Lamonta	Same	Good	Clay; calcareous in lower part.	Weathered, partly consolidated sandstone and agglomerate and old water-spread or colluvial mixed materials, mostly rhyolitic and acid igneous, but includes andesitic and basaltic materials.
Madras	Nearly level to rolling uplands.	Good	Clay loam over lime and silica hardpan or cemented layer.	Weathered pumiceous sandstone and agglomerate with a little fine wind-carried material in the upper part.
Metolius	Level and undulating bottom lands and alluvial fans.	Good	Sandy loam	Alluvial material high in pumice.
Odin	Shallow depressions and swales in uplands.	Imperfect to poor	Clay loam	Pumice sand with a small admixture of water-laid material.
Redmond	Level and very gently sloping uplands.	Moderately good	Light clay loam or heavy loam.	Pumice sand.

textured soils, but they are less fertile, more likely to erode, and need more water. Loose stones and rock outcrops prevent the economical cultivation of some soils.

The soils differ in structure from place to place. Only a few are strongly granular in the surface soil. Some are largely single grained.

The depth of most soils of the Area is between 16 and 26 inches, but depths range from a few inches to many feet. The underlying material is bedrock, hardpan, semiconsolidated material, loose gravel, cobblestones, or other material that obstructs root penetration. The soils that are less than 16 inches deep are mapped as shallow soils. Some soils that are more than 36 inches deep are mapped as deep soils.

Soil Types and Phases

In the following pages the soil types and phases and the miscellaneous land types of the Area are described in detail and their agricultural uses are discussed. Their location and distribution are shown on the soil map at the back of this report, and their approximate acreage and proportionate extent are shown in table 2.

This section was written at the time of the survey. Since that time there have been many changes in the use and management of the soils of the Deschutes Area. Later information on use and management can be obtained from the Oregon Agricultural Experiment Station and from the local representative of the Soil Conservation Service.

TABLE 2.—*Approximate acreage and proportionate extent of the soils mapped*

Soil	Acres	Percent
Agency gravelly loam, 0 to 3 percent slopes	123	(1)
Agency gravelly loam, 3 to 7 percent slopes	347	0. 1
Agency gravelly loam, 7 to 12 percent slopes	124	(1)
Agency gravelly loam, eroded, 3 to 7 percent slopes.	446	. 1
Agency gravelly loam, eroded, 7 to 12 percent slopes.	302	. 1
Agency loam, 0 to 3 percent slopes	5, 776	1. 7
Agency loam, 3 to 7 percent slopes	737	. 2
Agency loam, 7 to 12 percent slopes	93	(1)
Agency loam, 12 to 20 percent slopes	67	(1)
Agency loam, eroded, 0 to 3 percent slopes	1, 575	. 5
Agency loam, eroded, 3 to 7 percent slopes	519	. 2
Agency loam, eroded, 20 to 35 percent slopes	65	(1)
Agency loam, stony, 0 to 3 percent slopes	1, 517	0. 5
Agency loam, stony, 3 to 7 percent slopes	3, 698	1. 1
Agency loam, stony, 7 to 12 percent slopes	1, 005	. 3
Agency loam, stony, 12 to 20 percent slopes	495	. 1
Agency loam, stony, 20 to 35 percent slopes	114	(1)
Agency sandy loam, 0 to 3 percent slopes	2, 997	1. 0
Agency sandy loam, 3 to 7 percent slopes	181	. 1
Agency sandy loam, eroded, 0 to 3 percent slopes	908	. 3
Agency sandy loam, eroded, 3 to 7 percent slopes	215	. 1
Deschutes coarse sandy loam, over sandy material, 0 to 3 percent slopes	816	. 2
Deschutes loam, stony, 0 to 3 percent slopes	75	(1)

[1] Less than 0.1 percent.

TABLE 2.—*Approximate acreage and proportionate extent of the soils mapped*—Continued

Soil	Acres	Percent
Deschutes loamy coarse sand, over gravelly material, 0 to 3 percent slopes	1, 207	0. 4
Deschutes loamy coarse sand, over gravelly material, 3 to 7 percent slopes	117	(1)
Deschutes loamy sand, 0 to 3 percent slopes	18, 960	5. 6
Deschutes loamy sand, 3 to 7 percent slopes	1, 983	. 6
Deschutes loamy sand, 7 to 12 percent slopes	256	. 1
Deschutes loamy sand, eroded, 0 to 3 percent slopes	432	. 1
Deschutes loamy sand, over cinders, 0 to 3 percent slopes	49	(1)
Deschutes loamy sand, over cinders, 3 to 7 percent slopes	174	. 1
Deschutes loamy sand, over cinders, eroded, 3 to 7 percent slopes	94	(1)
Deschutes loamy sand, over cobbly material, 0 to 3 percent slopes	527	. 2
Deschutes loamy sand, over gravelly material, 0 to 3 percent slopes	3, 660	1. 1
Deschutes loamy sand, over gravelly material, 3 to 7 percent slopes	461	. 1
Deschutes loamy sand, over semicemented sandy material, 0 to 3 percent slopes	576	. 2
Deschutes loamy sand, over semicemented sandy material, 3 to 7 percent slopes	750	. 2
Deschutes loamy sand, over semicemented sandy material, 7 to 12 percent slopes	67	(1)
Deschutes sandy loam, 0 to 3 percent slopes	13, 048	4. 0
Deschutes sandy loam, 3 to 7 percent slopes	2, 018	. 6
Deschutes sandy loam, 7 to 12 percent slopes	152	(1)
Deschutes sandy loam, 12 to 20 percent slopes	98	(1)
Deschutes sandy loam, deep, 0 to 3 percent slopes	2, 077	. 6
Deschutes sandy loam, deep, 3 to 7 percent slopes	328	. 1
Deschutes sandy loam, deep over cinders, 0 to 3 percent slopes	168	(1)
Deschutes sandy loam, eroded, 7 to 12 percent slopes	90	(1)
Deschutes sandy loam, over cinders, 0 to 3 percent slopes	827	. 2
Deschutes sandy loam, over cinders, 3 to 7 percent slopes	172	. 1
Deschutes sandy loam, over cinders, eroded, 3 to 7 percent slopes	64	(1)
Deschutes sandy loam, over semicemented sandy material, 0 to 3 percent slopes	8, 183	2. 4
Deschutes sandy loam, over semicemented sandy material, 3 to 7 percent slopes	1, 191	. 4
Deschutes sandy loam, over semicemented sandy material, 7 to 12 percent slopes	61	(1)
Deschutes sandy loam, over semicemented sandy material, eroded, 12 to 20 percent slopes	62	(1)
Deschutes sandy loam, shallow, 0 to 3 percent slopes	566	. 2
Deschutes sandy loam, shallow, 3 to 7 percent slopes	199	. 1
Deschutes sandy loam, shallow over cinders, 0 to 3 percent slopes	77	(1)
Deschutes sandy loam, shallow over cinders, eroded, 3 to 7 percent slopes	79	(1)
Deschutes sandy loam, stony, 0 to 3 percent slopes	11, 088	3. 3
Deschutes sandy loam, stony, 3 to 7 percent slopes	1, 721	. 5
Deschutes sandy loam, stony, 7 to 12 percent slopes	128	(1)
Deschutes sandy loam, stony, over cinders, 3 to 7 percent slopes	65	(1)
Deschutes sandy loam, stony, over semicemented sandy material, 0 to 3 percent slopes	802	. 2
Deschutes sandy loam, stony, over semicemented sandy material, 3 to 7 percent slopes	274	0. 1
Deschutes sandy loam, stony, over semicemented sandy material, 7 to 12 percent slopes	43	(1)
Era sandy loam, 0 to 3 percent slopes	2, 495	. 7
Era sandy loam, 3 to 7 percent slopes	3, 458	1. 0
Era sandy loam, 7 to 12 percent slopes	1, 030	. 3
Era sandy loam, 12 to 20 percent slopes	226	. 1
Era sandy loam, eroded, 0 to 3 percent slopes	871	. 3
Era sandy loam, eroded, 3 to 7 percent slopes	2, 120	. 6
Era sandy loam, eroded, 7 to 12 percent slopes	735	. 2
Era sandy loam, eroded, 12 to 20 percent slopes	287	. 1
Gem clay loam, eroded, 3 to 12 percent slopes	50	(1)
Gem clay loam, eroded, 12 to 20 percent slopes	58	(1)
Gem clay loam, shallow, 7 to 12 percent slopes	92	(1)
Gem clay loam, shallow, eroded, 7 to 12 percent slopes	93	(1)
Gem loam, 3 to 7 percent slopes	105	(1)
Gem loam, 7 to 12 percent slopes	70	(1)
Gem loam, eroded, 7 to 12 percent slopes	123	(1)
Laidlaw sandy loam, 0 to 3 percent slopes	207	. 1
Laidlaw sandy loam, 3 to 7 percent slopes	612	. 2
Laidlaw sandy loam, 7 to 12 percent slopes	92	(1)
Laidlaw sandy loam, eroded, 7 to 12 percent slopes	69	(1)
Laidlaw sandy loam, eroded, 12 to 20 percent slopes	60	(1)
Lamonta loam, 0 to 3 percent slopes	1, 700	. 5
Lamonta loam, 3 to 7 percent slopes	3, 713	1. 1
Lamonta loam, 7 to 12 percent slopes	744	. 2
Lamonta loam, 12 to 20 percent slopes	128	(1)
Lamonta loam, eroded, 0 to 3 percent slopes	518	. 2
Lamonta loam, eroded, 3 to 7 percent slopes	1, 018	. 3
Lamonta loam, eroded, 7 to 12 percent slopes	470	. 1
Lamonta loam, eroded, 12 to 20 percent slopes	320	. 1
Lamonta loam, shallow, 0 to 3 percent slopes	100	(1)
Lamonta loam, shallow, 3 to 7 percent slopes	45	(1)
Lamonta loam, shallow, eroded, 3 to 7 percent slopes	133	(1)
Lamonta loam, shallow, eroded, 7 to 12 percent slopes	65	(1)
Lamonta loam, stony, 0 to 3 percent slopes	1, 072	. 3
Lamonta loam, stony, 3 to 7 percent slopes	2, 119	. 6
Lamonta loam, stony, 7 to 12 percent slopes	1, 863	. 6
Lamonta sandy clay loam, 0 to 3 percent slopes	312	. 1
Lamonta sandy clay loam, 3 to 7 percent slopes	490	. 1
Lamonta sandy clay loam, 7 to 12 percent slopes	74	(1)
Lamonta sandy clay loam, eroded, 0 to 3 percent slopes	340	. 1
Lamonta sandy clay loam, eroded, 3 to 7 percent slopes	414	. 1
Lamonta sandy clay loam, eroded, 7 to 12 percent slopes	386	. 1
Lamonta sandy clay loam, eroded, 12 to 20 percent slopes	96	(1)
Lamonta sandy clay loam, shallow, 0 to 3 percent slopes	47	(1)
Lamonta sandy clay loam, shallow, 3 to 7 percent slopes	70	(1)
Lamonta sandy clay loam, shallow, eroded, 3 to 7 percent slopes	246	. 1
Lamonta sandy clay loam, shallow, eroded, 7 to 12 percent slopes	169	. 1
Lamonta sandy clay loam, stony, 0 to 3 percent slopes	255	. 1
Lamonta sandy clay loam, stony, 3 to 7 percent slopes	411	. 1

[1] Less than 0.1 percent.

TABLE 2.—*Approximate acreage and proportionate extent of the soils mapped*—Continued

Soil	Acres	Percent
Lamonta sandy clay loam, stony, 7 to 12 percent slopes	259	0. 1
Lamonta sandy clay loam, stony, 12 to 20 percent slopes	433	. 1
Madras loam, 0 to 3 percent slopes	10, 759	3. 2
Madras loam, 3 to 7 percent slopes	3, 169	1. 0
Madras loam, 7 to 12 percent slopes	542	. 2
Madras loam, eroded, 0 to 3 percent slopes	3, 977	1. 2
Madras loam, eroded, 3 to 7 percent slopes	1, 598	. 5
Madras loam, eroded, 7 to 12 percent slopes	519	. 2
Madras loam, over sandstone, 0 to 3 percent slopes	1, 888	. 6
Madras loam, over sandstone, 3 to 7 percent slopes	483	. 1
Madras loam, over sandstone, eroded, 0 to 3 percent slopes	164	(1)
Madras loam, over sandstone, eroded, 3 to 7 percent slopes	127	(1)
Madras loam, stony, 0 to 3 percent slopes	634	. 2
Madras loam, stony, 3 to 7 percent slopes	1, 049	. 3
Madras loam, stony, 7 to 12 percent slopes	176	. 1
Madras loamy sand, over sandstone, 3 to 7 percent slopes	100	(1)
Madras loamy sand, over sandstone, eroded, 3 to 7 percent slopes	95	(1)
Madras sandy loam, 0 to 3 percent slopes	8, 313	2. 5
Madras sandy loam, 3 to 7 percent slopes	1, 982	. 6
Madras sandy loam, 7 to 12 percent slopes	246	. 1
Madras sandy loam, deep over sandstone, 0 to 3 percent slopes	246	. 1
Madras sandy loam, deep over sandstone, 3 to 7 percent slopes	97	(1)
Madras sandy loam, deep over sandstone, eroded, 3 to 7 percent slopes	150	(1)
Madras sandy loam, eroded, 0 to 3 percent slopes	3, 632	1. 1
Madras sandy loam, eroded, 3 to 7 percent slopes	985	. 3
Madras sandy loam, eroded, 7 to 12 percent slopes	62	(1)
Madras sandy loam, over sandstone, 0 to 3 percent slopes	3, 048	1. 0
Madras sandy loam, over sandstone, 3 to 7 percent slopes	1, 832	. 5
Madras sandy loam, over sandstone, 7 to 12 percent slopes	260	. 1
Madras sandy loam, over sandstone, 12 to 20 percent slopes	262	. 1
Madras sandy loam, over sandstone, eroded, 0 to 3 percent slopes	1, 174	. 3
Madras sandy loam, over sandstone, eroded, 3 to 7 percent slopes	2, 244	. 7
Madras sandy loam, over sandstone, eroded, 7 to 12 percent slopes	1, 170	. 3
Madras sandy loam, over sandstone, eroded, 12 to 20 percent slopes	809	0. 2
Madras sandy loam, shallow over sandstone, 0 to 3 percent slopes	171	. 1
Madras sandy loam, shallow over sandstone, 3 to 7 percent slopes	212	. 1
Madras sandy loam, shallow over sandstone, 12 to 20 percent slopes	48	(1)
Madras sandy loam, shallow over sandstone, eroded, 3 to 7 percent slopes	116	(1)
Madras sandy loam, shallow over sandstone, eroded, 7 to 12 percent slopes	206	. 1
Madras sandy loam, stony, over sandstone, 0 to 3 percent slopes	959	. 3
Madras sandy loam, stony, over sandstone, 3 to 7 percent slopes	953	. 3
Madras sandy loam, stony, over sandstone, 7 to 12 percent slopes	480	. 1
Madras sandy loam, stony, over sandstone, 12 to 20 percent slopes	747	. 2
Metolius sandy loam, 0 to 3 percent slopes	8, 332	2. 5
Metolius sandy loam, 3 to 7 percent slopes	1, 366	. 4
Metolius sandy loam, 7 to 12 percent slopes	310	. 1
Metolius sandy loam, eroded, 0 to 3 percent slopes	1, 646	. 5
Metolius sandy loam, eroded, 3 to 7 percent slopes	612	. 2
Metolius sandy loam, terrace position, 0 to 3 percent slopes	182	. 1
Metolius sandy loam, terrace position, 3 to 7 percent slopes	72	(1)
Odin clay loam, 0 to 3 percent slopes	285	. 1
Odin clay loam, 3 to 7 percent slopes	43	(1)
Odin sandy loam, 0 to 3 percent slopes	208	. 1
Pits and dumps	7	(1)
Redmond clay loam, 0 to 3 percent slopes	134	(1)
Redmond loam, 0 to 3 percent slopes	405	. 1
Redmond sandy loam, 0 to 3 percent slopes	3, 282	1. 0
Redmond sandy loam, 3 to 7 percent slopes	365	. 1
Redmond sandy loam, deep, 0 to 3 percent slopes	439	. 1
Riverwash	91	(1)
Rough broken land, Era and Deschutes soil materials, 12 to 50 percent slopes	3, 351	1. 0
Rough stony land, Agency and Deschutes soil materials, 12 to 60 percent slopes	45, 029	13. 4
Scabland, 0 to 3 percent slopes	6, 132	1. 8
Scabland, 3 to 12 percent slopes	82, 887	25. 0
Volcanic ash, 0 to 3 percent slopes	40	(1)
Total	336, 795	100. 0

[1] Less than 0.1 percent.

Agency gravelly loam

Almost all of this well-drained soil lies north of the Crooked River in nearly level to somewhat rolling plains. The natural vegetation consists of big sagebrush, rabbitbrush, bunchgrasses, scattered junipers, and associated plants. The normal annual precipitation is 8.5 to 10 inches.

The parent material of this soil consists of old water-laid or partly consolidated sedimentary materials and volcanic materials. In most places the upper part of the soil was derived from the somewhat consolidated agglomerates and sandstones of the Dalles formation *(5)*[2] mixed with a little fine pumice and volcanic ash. The lower part of the profile contains fragments of basalt or material weathered from basalt. The underlying material is basalt or other lava bedrock.

Typical profile:

0 to 9 inches, light brownish-gray to grayish-brown noncalcareous gravelly loam; very dark grayish brown and friable when moist.

9 to 18 inches, brown to grayish-brown noncalcareous gravelly clay loam; breaks into subangular blocky aggregates; mildly alkaline.

18 to 24 inches, brown to pale-brown or light yellowish-brown gravelly clay loam; contains basalt stones; breaks into subangular blocky aggregates; noncalcareous except in places in the lower part or on the under side of pebbles and stones.

24 inches+, lime-coated fragments of basalt that overlie basalt bedrock.

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[2] Italic numbers in parentheses refer to Literature Cited, p. 81.

The depth to the underlying rock ranges from about 1½ to 3 feet. In some areas the underlying material is partly consolidated sandstone or agglomerate instead of basalt.

This soil contains many red rhyolitic and dark-colored basaltic or andesitic pebbles, but the content varies from place to place. In some areas subangular or rounded cobblestones occur. Commonly there are enough pebbles to interfere with tillage. The upper part of the soil contains small amounts of fine pumice.

Although low in organic matter, this soil is moderately fertile. The surface soil is permeable to water and roots. The subsoil is slightly less permeable. The underlying basalt is relatively impermeable, but in places fissures or cracks allow water to move downward. Because of the content of pebbles and the moderate depth of the soil, water-holding capacity is moderate to somewhat low.

To show variations in slope and erosion, five phases of this soil are mapped.

Agency gravelly loam, 0 to 3 percent slopes (Aa).—This soil occurs in several small tracts in Jefferson County in association with other Agency soils and soils of the Era, Madras, and Lamonta series. Runoff is fairly slow, and water erosion is slight. In a few places wind erosion is moderate.

Use and management (subgroup 2A)[3].—About 80 percent of this soil is used for grain under a dryland summer-fallow system. Most of the rest is idle or in annual or perennial grasses and used for grazing. Average yields of grain are low.

Some of this soil probably will be irrigated under the Deschutes Irrigation Project. The soil appears to be only fair to good for irrigated crops. The gravel impedes cultivation and would hinder the growth and harvesting of potatoes. If irrigated, the soil would be suited to permanent pasture, hay, clover for seed, and grain.

Management needs are similar to those of Agency loam, 0 to 3 percent slopes. Growth of weeds should be prevented so that the available moisture can be used by crops and pasture plants. While the soil is fallow, much of the stubble should be left on the ground to prevent wind erosion.

Agency gravelly loam, 3 to 7 percent slopes (Ab).—This soil is gently sloping or undulating; consequently, it has more rapid runoff than Agency gravelly loam, 0 to 3 percent slopes, and is more likely to erode if irrigated. Distribution and control of irrigation water will be more difficult.

Use and management (subgroup 2B).—About 60 percent of this soil is in sagebrush and grass; about 10 percent has been cropped but is now in grass. These areas are used for grazing. The carrying capacity is rather low. The rest of this soil has been used for grain under a dryland summer-fallow system. Average yields are low.

Some of this soil probably will be irrigated, though it is only fair for irrigated crops. The relief will make it difficult to distribute water evenly, and the gravel impedes cultivation. This soil is better suited to permanent grass-legume pasture, hay, clover seed, and grain than to potatoes or other row crops.

Agency gravelly loam, 7 to 12 percent slopes (Ad).—Small areas of this sloping or rolling soil are widely scattered in Jefferson County. Runoff is greater than on Agency gravelly loam, 0 to 3 percent slopes. This soil is fair to poor in workability and is likely to erode if irrigated.

Use and management (subgroup 2C).—About 60 percent of this soil is in sagebrush and grass and is used for grazing. The rest is used for dry-farmed grain. Yields are low.

Some areas of this soil lie below the canals and possibly will be irrigated. These areas are best suited to permanent grass-legume pasture. The soil would be poor for irrigated crops. Management needs are similar to those of Agency gravelly loam, eroded, 7 to 12 percent slopes.

Agency gravelly loam, eroded, 3 to 7 percent slopes (Ac).—This soil is moderately eroded. Most of it has lost one-fourth or more of the original surface soil through erosion. Deep plowing may turn up some of the subsurface soil or subsoil. Runoff has caused most of the erosion, but in places wind has caused some. In most areas there is enough gravel on the surface and in the surface soil to interfere with cultivation, especially with the harvesting of potatoes. In some areas the pebbles are subangular rock fragments, and in a few places cobblestones occur.

Use and management (subgroup 2B).—Nearly 40 percent of this soil has been cropped but is now idle or in annual or perennial grasses. Another 15 percent has a cover of sagebrush and grass. All these tracts are used for range. Most of the rest of the soil is used for dry-farmed grain and left fallow every other summer. Average yields are low.

Some of this soil will be irrigated. It is only fairly well suited to irrigation. It is better suited to permanent grass-legume pasture, hay, clover seed, vetch seed, and grain than to potatoes or other row crops. Management needs are similar to those of Agency loam, 3 to 7 percent slopes.

It is difficult to distribute water evenly without causing erosion. The corrugation method is probably the best method of irrigating most areas. Runs should be short. Deep cuts should not be made when this soil is being leveled.

Agency gravelly loam, eroded, 7 to 12 percent slopes (Ae).—Most of this soil has lost between 25 and 75 percent of the surface soil through erosion. A few acres have lost almost all the surface soil. Shallow gullies have formed in a few places east of Madras. Runoff has caused most of the erosion. Some wind erosion may have occurred. Runoff is medium where the soil is not protected by vegetation. The erosion hazard under irrigation would be high. Workability is fair to poor.

Use and management (subgroup 2C).—About 20 percent of this soil has a cover of sagebrush and grass; slightly more than 30 percent has been cultivated but is now idle or in annual or perennial grass. These tracts are used for grazing. Their carrying capacity is low. Nearly half of this soil is used for dry-farmed wheat under a summer-fallow system. Average yields are low, perhaps about 7 bushels per acre.

The density and vigor of the grasses could be improved by controlling grazing. Some areas may need to be reseeded to crested wheatgrass.

Most of the straw and stubble of dry-farmed grain should be returned to the soil to supply organic matter. Stubble mulching and contour tillage help to reduce erosion. A rotation of 6 or 8 years of crested wheatgrass

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[3] The use suitability and suggested management of the soils of the Area are given by management groups and subgroups in the section, Use and Management of Soils.

and 8 years of alternate wheat and fallow is well suited to this soil.

Some of this soil lies below the irrigation canal, and probably part of it will be irrigated. If irrigated it will be suitable for grass-legume pasture. It is poorly suited to irrigated crops.

Agency loam

Agency loam occurs in Jefferson County, most extensively on the Agency Plains and near Culver and Opal City. Much of it will be irrigated by the Deschutes Irrigation Project. Practically all of this soil lies north of the Crooked River. Most of it is nearly level or gently undulating, but some is strongly undulating, rolling, or hilly. It is well drained. The natural vegetation consisted of big sagebrush, rabbitbrush, bunchgrasses, scattered junipers, and associated plants. The normal annual precipitation is about 8.5 to 10 inches.

This soil was derived from old sedimentary materials and volcanic materials. Most of the sediment was of volcanic origin. The upper part of the soil developed mainly from partly consolidated sedimentary materials weathered from the Dalles formation. This formation consists of sandstones, agglomerates, gravels, sands, tuffs, cinders, ashes, and agglomerate-mudflows (*5*). The sandstones and agglomerates are dominant in this region. They contain large amounts of rhyolitic and other acidic igneous materials and materials that are andesitic and more basic. The upper part of the profile may contain a small amount of fine pumice, volcanic ash, or loess. The lower part of the profile typically has been affected by basaltic rock fragments and materials weathered from these fragments.

Agency loam is associated with the Madras, Era, and Lamonta soils. The Agency soils generally lack the caliche layer that is characteristic of the Madras soils. Agency soils have been affected more than Madras by basaltic materials. They differ from the Era and Lamonta soils in the development and texture of the subsoil. The Agency subsoil is fine textured and moderately developed, whereas the subsoil of the Era soils is coarser in texture. The texture of the Lamonta subsoils is finer and more dense than that of the Agency. Agency soils are somewhat similar to Redmond but contain less pumice.

Typical profile:

to 10 inches, light brownish-gray or grayish-brown noncalcareous slightly hard loam; very fine granular structure; when moist, very dark grayish brown and friable; neutral reaction; grades to the layer below.

to 20 inches, brown noncalcareous hard clay loam that breaks into moderate fine subangular blocky or rounded aggregates; aggregates thinly coated with darker glossy material; few to moderate number of fine pores; when moist, dark brown to dark grayish brown and firm to friable; when wet, slightly sticky and plastic; mildly alkaline.

20 to 28 inches, brown to pale-brown or light yellowish-brown hard clay loam that breaks into moderate fine subangular blocky aggregates; aggregates have a thin colloidal coating; few to moderate number of fine pores; when moist, dark brown and firm to friable; when wet, slightly sticky and plastic; mildly to moderately alkaline; noncalcareous except in places in the lower part; contains a few or a moderate number of pebbles and angular basalt stones as much as 8 or 10 inches in diameter; some of the pebbles and stones are lime coated on their lower sides.

28 inches +, lime-coated fragments of basalt over basalt bedrock.

In some areas the surface soil is sandy loam or fine sandy loam, and the subsoil is sandy clay loam. In a few areas the subsoil is loam or clay. The depth to the underlying rock ranges from about 20 to 35 inches. In some areas, particularly on the Agency Plains, the underlying material is partly consolidated sandstone or other sedimentary material, and the soil is similar to Madras loam.

The upper part of this soil contains a small amount of pumice the size of fine and medium sand. This pumice may have been derived from deposits that fell from the air following a volcanic eruption, or from the sedimentary parent material. In most places the upper layers contain a few red rhyolitic and dark-colored basaltic or andesitic pebbles. In the lower layers the pebbles are more numerous. The organic-matter content is low.

The surface soil is permeable to water and roots; the subsoil is slightly less permeable. The underlying basalt or other rock commonly is relatively impermeable, but in places water can move downward through fissures or cracks. Under natural conditions, the water table does not affect the soil, but excessive irrigation may produce a perched water table above the underlying rock in depressed areas. In such places, salts may accumulate, but normally the soil is not affected by soluble salts or alkali.

To show variations in slope, erosion, and stoniness, 12 phases of this soil are mapped.

Agency loam, 0 to 3 percent slopes (Af).—Most of this soil is in the Agency Plains and in the plains near Culver, Metolius, and Opal City. Runoff is slow, and water erosion is negligible or slight. Slight wind erosion has occurred in places. This soil is low in organic matter and nitrogen, but generally it is moderately fertile. The water-holding capacity is moderate to somewhat high.

Use and management (subgroup 2A).—Nearly all of this soil is used for grain under a dry-farming system and left fallow every other summer. About 43 percent of this soil is used for wheat, 1 percent for barley, and 5 percent for small grains to be cut for hay. Each year an equal area is summer-fallowed. A few acres are used for rye and for grazing.

Generally about 85 percent of the wheat is winter wheat, which appears better suited to this soil than spring wheat. In spring the stubble generally is plowed and a trashy cover is left for the period of fallow. To control weeds a rod weeder or other tillage implement is used two or three times during the summer. The wheat is planted late in October or early in November. Fertilizer or other amendments are rarely used. Yields, which vary with the amount and distribution of rainfall, are low. The average yield of dry-farmed spring wheat is a little less than that of winter wheat. The wheat stubble may be used for grazing. About 5 acres is required to graze a 1,000-pound cow for 1 month in years of high yields, and about 10 acres is needed in years of low yields (*10*).

Because rainfall is low and the soil is moderately deep, this soil is only moderately to poorly suited to dry-farmed wheat and other small grains. Crop residues should be returned to the soil, to supply organic matter. The stubble and straw should not be burned. A stubble mulch helps to reduce wind and water erosion. If the combine is equipped to spread straw at the time of the harvest, subsequent plowing will be made easier. Timely cultivation to control weeds helps to conserve moisture. The choice of crop rotations suitable for dry farming is limited.

A considerable part of this soil will be irrigated. Probably about the same kind of crops will be grown on the irrigated areas as are now grown on the Redmond and Deschutes soils in Deschutes County—alfalfa, potatoes, oats, barley, and wheat; Ladino, alsike, and red clovers for hay and seed; and peas for seed. Under irrigation, this soil will be suitable for the same crops as Redmond loam, 0 to 3 percent slopes, and after a few years of cropping it will produce slightly higher yields.

This soil should be well suited to many irrigated crops. In most areas it will need only slight leveling to prepare it for irrigation. Because the subsoil is fine textured and the soil is only moderately deep, deep cuts should be avoided while grading. The strip-border system would be suitable for irrigating small grains, hay, and pasture, and the furrow system for row crops.

Organic matter must be added to this soil to make it highly productive under irrigation. Organic matter can be added by several methods, including the use of a crop rotation that includes legumes and grasses, the conservation and return to the soil of all manures, and the proper use of crop residues. Organic matter can be effectively and quickly added by turning under a green-manure crop of annual sweetclover. The sweetclover can be sown broadcast when the grain crop, which is seeded early, is first irrigated. If it is irrigated once after the grain harvest, the sweetclover will grow rapidly. It can be plowed under later in the fall.

Fertilizer requirements should be determined by field trials. Greenhouse tests (*10*) on several associated soils and experience with somewhat similar soils under irrigation in Deschutes County indicate that (1) for several crops this soil is deficient in nitrogen; (2) legumes may respond well to sulfur; and (3) potatoes and other row crops respond to a complete fertilizer.

Agency loam, 3 to 7 percent slopes (Ah).—Almost all of this soil lies north of the Crooked River. Many of the areas are associated with Agency loams that are less strongly or more strongly sloping than this soil. A few areas are on high benches surrounded by Rough stony land, which is in the river canyons.

This soil is easy to till. It is slightly shallower, on the average, than Agency loam, 0 to 3 percent slopes. Runoff is slow; nevertheless, there will be some difficulty in irrigating this soil without causing erosion.

Use and management (subgroup 2B).—About 45 percent of this soil is under a natural cover of sagebrush and grass. From 10 to 15 percent was once in cultivation, but it is now idle or in annual or perennial grasses. These areas are used for grazing. Under common practices about 8 to 9 acres are required to graze a 1,000-pound cow for 1 month. Most of the rest of this soil is used for dry-farmed wheat and is left fallow every other summer. Yields are about the same as or slightly less than on Agency loam, 0 to 3 percent slopes.

One-half to two-thirds of Agency loam, 3 to 7 percent slopes, will be irrigated under the Deschutes Irrigation Project; the rest lies above the canal or in positions to which water cannot easily be conveyed. This soil is fairly well suited to irrigation. Use suitability and management needs are similar to those of Agency loam, 0 to 3 percent slopes, but, because of the higher hazard of erosion, this soil is somewhat less well suited to potatoes and other row crops. It should be used as much as possible for alfalfa, clover, or pasture. Additions of organic matter are especially important. Smooth bromegrass or big bluegrass or some other grass should be grown with the alfalfa. Because water spreads less uniformly on this soil than on Agency loam, 0 to 3 percent slopes, productivity may be slightly lower.

Irrigating this soil may cause it to erode unless the water is applied carefully. The corrugation method may be better suited to the stronger slopes than the strip-border method. If the strip-border method is used to irrigate the gentler slopes, the runs should be short and the strips narrow. This soil should be carefully leveled crosswise between borders, but, because it is moderately shallow, deep cutting should be avoided.

Agency loam, 7 to 12 percent slopes (Al).—This sloping or rolling soil is shallower than Agency loam, 0 to 3 percent slopes. It occurs in small areas east of Metolius and near Haystack Butte and Juniper Butte. It is associated with Era, Lamonta, and other Agency soils. About one-fourth of the acreage is moderately eroded. Workability is good. Included are about 20 acres in which the surface soil is a sandy loam.

Use and management (subgroup 2C).—Almost all of this soil is used for nonirrigated range. Sagebrush and grass cover about three-fourths of the acreage; such areas have a grazing capacity of about 10 acres a cow-month. The rest of the soil has been cultivated but is now idle or in annual or perennial grasses.

This soil is poorly suited to irrigation, and probably none of it will be irrigated. Some of it lies above the canal and some in other locations to which it would be difficult to supply water. Particularly on row crops, control and distribution of water would be difficult.

Agency loam, 12 to 20 percent slopes (Am).—This inextensive soil occurs in a few scattered areas in Jefferson County. It is shallower than Agency loam, 0 to 3 percent slopes, and, because of its stronger slopes, has more rapid runoff and is more likely to erode. Furthermore, this soil differs more from place to place. Included are some areas in which the surface soil is sandy loam.

Use and management (subgroup 2D).—Slightly more than one-third of this soil is in sagebrush and grass; almost as much of it has been cultivated but is now either idle or in grass. These areas are used for grazing. The rest of the soil is used for dry-farmed grain. Yields are low. Probably none of this soil will be irrigated, because of its location and the difficulty of distributing water without causing serious erosion.

Agency loam, eroded, 0 to 3 percent slopes (Ag).—This soil has been moderately eroded by wind. A considerable part of it has lost one-fourth or more of the original surface soil. Deep plowing may turn up some of the subsurface soil or upper subsoil.

This soil is similar to the associated Agency loam, 0 to 3 percent slopes, except that it is more eroded and somewhat less fertile and the thickness of the surface soil is generally 2 to 4 inches less.

Use and management (subgroup 2A).—Most of this soil is used for wheat under a dryland summer-fallow system. Yields are low.

Much of this soil will be irrigated under the Deschutes Irrigation Project. Use suitability under irrigation would be similar to that of Agency loam, 0 to 3 percent slopes, but larger additions of organic matter are needed, and slightly larger applications of nitrogen for potatoes or row crops may be effective. Wind erosion can be retarded by stripcropping, by stubble mulching, and by keeping the surface rough and uneven.

Agency loam, eroded, 3 to 7 percent slopes (Ak).—This soil is gently sloping or undulating. It has been moderately eroded by water or wind, or both. A considerable part of the acreage has lost about one-fourth or more of the surface soil, and deep plowing turns up some of the subsurface soil or upper subsoil. This soil is like Agency loam, 0 to 3 percent slopes, but it is more eroded and the thickness of the surface soil generally is 2 to 4 inches less.

Use and management (subgroup 2B).—The present use, suitability for use, and management needs of this soil are similar to those of Agency loam, 3 to 7 percent slopes. Average yields are slightly lower. The need for additions of organic matter is slightly greater on this soil, and somewhat larger applications of nitrogen fertilizer may be effective.

Agency loam, eroded, 20 to 35 percent slopes (An).—This inextensive soil occurs in a few scattered areas near Haystack Butte. Because of the moderately steep or steep slopes, runoff is medium or rapid. Much of this soil is moderately eroded. Except for its thinner surface soil and shallower depth to bedrock, this soil resembles Agency loam, 0 to 3 percent slopes.

Use and management (group 5).—All of this soil is used for range. Its carrying capacity is low. Most of it is covered with sagebrush and grass. A few acres have been dry-farmed to grain, but these areas are now in grass or are idle. Because of the strong slopes, this soil is not well suited to dry farming or to irrigation. It is best suited to range. The carrying capacity could be increased if grazing were controlled and if more areas were seeded to crested wheatgrass and bulbous bluegrass.

Agency loam, stony, 0 to 3 percent slopes (Ao).—All of this soil is in Jefferson County. Most of it is too stony to be tilled; a few areas are less stony and could be made suitable for cultivation by removing the stones. Most of the stones are angular fragments of basalt. They range up to 20 inches in diameter. The basalt bedrock outcrops in places. About one-fourth of the acreage is eroded; these areas are identified on the soil map by erosion symbols.

Included are some areas in which the subsoil is a stony loam that is coarser than the typical subsoil of Agency loam. In other areas the subsoil is finer than typical.

Use and management (group 6).—Almost all of this soil is covered with sagebrush and grass and is used for grazing. This stony soil would be difficult to till so that grass could be seeded. The pastures should not be overgrazed and should not be grazed too early in spring or too late in fall.

This soil is not suitable for crops. If it can be irrigated, permanent pastures should do well. Applications of sulfur and nitrogen should be effective. Subdividing the pasture into three or four tracts to be grazed in rotation should increase carrying capacity.

Agency loam, stony, 3 to 7 percent slopes (Ap).—This extensive soil is gently sloping or undulating. Runoff therefore is more rapid than on Agency loam, stony, 0 to 3 percent slopes, and areas not well protected by vegetation may erode. About 40 percent of this soil is moderately eroded.

Use and management (group 6).—Most of this soil is too stony to be tilled. Its use, suitability for use, and management needs are similar to those of Agency loam, stony, 0 to 3 percent slopes. Because it is more strongly sloping, however, this soil would be more difficult to irrigate for permanent grass-legume pasture.

Agency loam, stony, 7 to 12 percent slopes (Ar).—This sloping or rolling soil is similar to Agency loam, stony, 0 to 3 percent slopes, but is more likely to erode if not protected by vegetation.

This soil is in management group 6. It is more difficult to irrigate evenly than Agency loam, stony, 0 to 3 percent slopes. Many areas are not suitable for irrigated pasture.

Agency loam, stony, 12 to 20 percent slopes (As).—Because this soil is very strongly sloping or hilly, runoff is more rapid and the erosion hazard is greater than on Agency loam, 0 to 3 percent slopes. The many stones on and in the surface soil prevent ordinary tillage.

This soil differs from place to place. About 80 acres of this mapping unit is predominantly gravelly instead of stony and consequently is less difficult to till than the stony areas. In places the subsoil is loam or stony loam instead of clay loam or stony clay loam. Almost 60 percent of this soil has been moderately eroded by water or wind, or both. Eroded areas are marked on the soil map by erosion symbols.

Use and management (group 6).—Nearly all of this soil is covered with sagebrush and grass and is used for grazing, the use to which it is best suited. Because of the strong slope, it would be very difficult to control irrigation water.

Agency loam, stony, 20 to 35 percent slopes (At).—If this moderately steep to steep soil is not protected by vegetation, runoff is likely to be rapid and erosion may occur. Nearly one-half of this soil is moderately eroded. In some areas the surface soil is sandy clay loam or heavy loam and the subsoil is heavy clay loam or clay. Many stones are on the surface and in the surface soil, and bedrock outcrops in places.

This soil is not suited to crops or irrigated pasture. It is best suited to range. Grazing should be regulated so that the perennial bunchgrasses can increase in density and vigor. This soil is in management group 6.

Agency sandy loam

Almost all of the Agency sandy loam in the Area is in Jefferson County. This soil occurs in the upland. Drainage, climate, and natural vegetation are similar to those described for the associated Agency loam.

This soil is more easily tilled than Agency loam, but its water-holding capacity and natural fertility are lower. It developed from slightly sandier parent material, and it probably contains somewhat more pumice. It is moderately developed.

Representative profile:

0 to 9 inches, light brownish-gray or grayish-brown noncalcareous sandy loam; neutral reaction; weak very fine granular structure; when moist, very dark grayish brown and very friable.

9 to 19 inches, brown noncalcareous hard clay loam or sandy clay loam; breaks into fine subangular blocky aggregates that have thin colloidal coating; when moist, dark brown to dark grayish brown and firm to friable; mildly alkaline.

19 to 26 inches, brown to pale-brown or light yellowish-brown hard clay loam or sandy clay loam; breaks into fine subangular blocky aggregates that have thin colloidal coating; when moist, dark brown and firm to friable; mildly to moderately alkaline; noncalcareous except in the lower part;

few or moderate number of pebbles and angular basalt stones, some of which are coated with lime on their under sides.

26 inches +, lime-coated fragments of basalt, which overlie basalt bedrock.

The depth to the underlying bedrock ranges from 20 to 35 inches. In some areas the soil is underlain by partly consolidated sandstone or other sedimentary material instead of lava. In most places the soil contains a few red rhyolitic and dark-colored pebbles. The upper part of the profile contains a small amount of pumice.

Included are a few small tracts that have a loam surface soil and a few areas that have a loam or a clay subsoil.

The surface soil and the subsoil are permeable to water and roots. The underlying bedrock is relatively impermeable, but in places there are fissures through which water can drain. Under natural conditions, this soil is not affected by the water table or by salts or alkali.

To show differences in slope and erosion, four phases of Agency sandy loam are mapped.

Agency sandy loam, 0 to 3 percent slopes (Au).—This soil occurs mostly in Agency Plains and in the plains near Culver, Metolius, and Opal City. Runoff is slow, and water erosion has been negligible or slight. Slight wind erosion has occurred in places.

Use and management (subgroup 2A).—Nearly three-fourths of this soil is used for dry-farmed wheat under a summer-fallow system similar to that used on Agency loam, 0 to 3 percent slopes. A small part of the total area was formerly cultivated but is now idle or in grass; almost one-fourth of the soil has a sagebrush-grass cover. These tracts are used for grazing, but the carrying capacity is low.

Because of its coarser texture and lower water-holding capacity, average yields on this soil are somewhat lower than on Agency loam, 0 to 3 percent slopes. Management needs of the two soils are similar, but this soil has a slightly greater need for nitrogen, phosphorus, and organic matter than Agency loam, 0 to 3 percent slopes. Stripcropping would help to reduce wind erosion.

Much of this soil will be irrigated under the Deschutes Irrigation Project. It should be fairly good for alfalfa, potatoes, and small grains, and for legumes grown for seed, and good for Ladino, alsike, and red clovers, vetch, and peas. Apparently it is one of the better soils for Ladino clover seed. It is similar to Agency loam, 0 to 3 percent slopes, in use suitability and management needs under irrigation, but may yield less under the same kind of management. This soil should be irrigated somewhat more frequently than Agency loams, and more lightly by use of larger heads and shorter runs.

Agency sandy loam, 3 to 7 percent slopes (Aw).—Because this soil is more strongly sloping, it has more rapid runoff and a more serious erosion hazard than Agency sandy loam, 0 to 3 percent slopes. Row crops are more difficult to irrigate properly without causing erosion.

Use and management (subgroup 2B).—About 20 percent of this soil has a sagebrush cover; about 40 percent, formerly cultivated, is idle or in annual or perennial grasses. These tracts are used for grazing. Most of the rest of the soil is used for dry-farmed wheat.

A considerable part of this soil will be irrigated. The soil is similar in crop suitability and management needs to Agency loam, 3 to 7 percent slopes, but its need for additional organic matter, nitrogen, and phosphorus is somewhat greater. Furthermore, irrigation water should be applied somewhat more frequently, in slightly smaller amounts, under larger heads, and in shorter runs. Yields under similar management probably will be slightly less than on Agency loam, 3 to 7 percent slopes.

Agency sandy loam, eroded, 0 to 3 percent slopes (Av).—This soil has lost one-fourth or more of the original surface soil through wind erosion. Water erosion has been negligible. Some of the subsurface soil and upper subsoil may be turned up by deep plowing; then the plow layer may be slightly finer in texture, slightly less permeable, and somewhat browner than it was before plowing.

Use and management (subgroup 2A).—Crop suitability and management needs are similar to those of Agency sandy loam, 0 to 3 percent slopes, but average yields are somewhat less. Wind erosion can be reduced by stubble mulching, stripcropping, and keeping the surface rough and uneven.

Much of this soil will be irrigated. Under irrigation it will need somewhat larger additions of organic matter and nitrogen than Agency sandy loam, 0 to 3 percent slopes. Organic matter can be added quickly by growing an annual sweetclover with a small grain and plowing the sweetclover under in fall after the grain is harvested.

Agency sandy loam, eroded, 3 to 7 percent slopes (Ax).—This soil has been moderately eroded by wind or water, or both. A small part of the subsurface soil or upper subsoil may be turned up by deep plowing.

Use and management (subgroup 2B).—Most of this soil is used for dry-farmed wheat. Average yields are low. About 12 percent of the soil, formerly cropped, is idle or in grass. An additional 8 percent is still under the natural cover of sagebrush and grass.

Probably a considerable part of this soil will be irrigated. This soil is similar in crop suitability and management requirements to Agency loam, 3 to 7 percent slopes, but its need for organic matter and nitrogen is greater. Furthermore, water should be applied more frequently and in slightly smaller amounts, under larger heads and in shorter runs.

This soil should be kept in legumes or pasture two-thirds or more of the time. Organic matter can be quickly and effectively added by plowing under a crop of annual sweetclover sown in the grain.

Deschutes coarse sandy loam

This soil occurs near Cloverdale on the nearly level outwash plain that slopes gently from the Cascade Mountains. The normal annual precipitation—probably about 12 or 13 inches—is somewhat higher than for most of the Deschutes Area, but apparently the frost-free season is shorter. The natural vegetation is mainly juniper, big sagebrush, and grasses. Ponderosa pine and bitterbrush grow about one-half mile to the westward.

Much of the upper part of this soil was derived from pumice, with which some water-laid material is mixed. The water-laid material originated from lava. The lava was mainly andesite and basalt, but it included some rhyolitic material.

This soil is associated with Deschutes loamy sand, over gravelly material, 0 to 3 percent slopes, and Deschutes sandy loam, over semicemented sandy material, 0 to 3 percent slopes. It has a looser, more pervious substratum than the associated soils, and it is lower in water-holding capacity.

Deschutes coarse sandy loam is very slightly developed; its subsoil is slightly finer in texture and more compact than its surface soil.

Typical profile:

0 to 7 inches, grayish-brown to dark grayish-brown or brown coarse sandy loam; soft; single grain; contains a few or a moderate number of small lava pebbles and a moderate amount of pumice the size of coarse, medium, and fine sand; when moist, very dark grayish brown and very friable.
7 to 16 inches, grayish-brown to brown very porous light coarse sandy loam; single grain; contains pumice and pebbles, like layer above; when moist, very dark grayish brown and very friable.
16 to 28 inches, similar to material in layer above but firmer and more gravelly.
28 inches+, gray and dark-gray loose gravelly sand or coarse sand; single grain; when moist, very dark gray; subangular and rounded pebbles, mostly of medium- and dark-colored lava, but some reddish or light-colored, and generally less than 1 inch in diameter; layer contains a little pumice sand.

The organic-matter content is generally low. In places it is somewhat higher than typical, and in such places the surface soil is dark grayish brown. The soil is noncalcareous throughout; the reaction ranges from neutral or slightly acid to mildly alkaline. The content of gravel varies to some extent. In places the subsoil is loamy coarse sand or gravelly loamy sand.

The surface soil and subsoil are somewhat rapidly permeable to water and allow roots to penetrate freely. Water passes very rapidly through the underlying loose gravelly sand, which has a low water-holding capacity. Consequently, this soil is somewhat excessively drained and needs large amounts of water for irrigation. This soil has not been affected by salts or alkali, and the erosion hazard is negligible.

Only one phase of Deschutes coarse sandy loam is mapped.

Deschutes coarse sandy loam, over sandy material, 0 to 3 percent slopes (Da).—This soil differs from a typical Deschutes soil in the following ways: (1) In most places it is noncalcareous; (2) it has a slightly darker colored surface soil; (3) it contains less pumicy material and more water-laid material; (4) it occurs in an area of higher precipitation; and (5) internal drainage is more rapid.

Use and management (subgroup 1A).—Nearly all of this soil is used for irrigated crops and pasture. The principal crops are alfalfa, oats, barley, wheat, alsike clover for hay and seed, vetch for seed, and potatoes. About 6 percent of the soil has a juniper-sagebrush-grass cover.

This soil is managed in about the same way as Deschutes sandy loam, 0 to 3 percent slopes, but it requires more water for irrigation, and it produces slightly lower yields.

Deschutes loam

Deschutes loam developed from less sandy material than Deschutes sandy loam. The two soils have the same type of natural vegetation. Deschutes loam is similar to Redmond loam except that its subsoil is less compact and more coarse textured.

Representative profile:

0 to 11 inches, light brownish-gray or grayish-brown, noncalcareous, slightly hard, light loam; contains a large amount of light yellowish-brown or very pale brown pumice particles the size of coarse to very fine sand.
11 to 23 inches, pale-brown or light yellowish-brown loam that grades toward light brownish gray or grayish brown; noncalcareous; breaks under considerable pressure of the fingers into weak subangular blocky aggregates ¼ to ¾ inch in diameter; contains pumice similar to that in layer above.
23 to 28 inches, material similar to that in layer above except that it is slightly calcareous.
28 inches +, basalt bedrock, generally thinly coated with lime.

During rains, the pumice in the surface soil accumulates in miniature depressions. When the surface is dry, these spots are browner than other parts of the surface soil. In most places small angular fragments or rounded pebbles of basalt or other lava rock occur throughout the profile.

This soil is nonsaline. It is relatively low in organic matter and nitrogen. Above the bedrock it is moderately permeable to water, roots, and air. Water drains through the bedrock only if there are fissures or openings.

Deschutes loam, stony, 0 to 3 percent slopes (Db).—This inextensive soil occurs in scattered tracts near Terrebonne and southwest of Redmond. It has enough angular and subangular stones—generally basalt—to interfere with tillage. In most places, however, there are not enough stones to prevent all cultivation. Stones have been removed from a few tracts. The water-holding capacity is moderate, and the soil is easily irrigated.

Use and management (subgroup 1A).—About one-half of this soil has been cultivated, but much of this acreage is now idle or in grass. The rest of the soil is under its natural cover.

This soil is fairly well suited to irrigated grass-legume pasture. Areas that can be irrigated can be made suitable for cropping by removing the stones. If stones are removed, the management needs of this soil would be similar to those of Deschutes sandy loam, 0 to 3 percent slopes, but this soil would be better suited to most crops, and it would need less frequent irrigation.

Deschutes loamy coarse sand

Deschutes loamy coarse sand has a slightly sandier surface soil and more fine material in its substratum than Deschutes coarse sandy loam. It is coarser than Deschutes loamy sand, over gravelly material, with which it occurs in Deschutes County in the western part of the Area.

Typical profile:

0 to 8 inches, brown or grayish-brown soft loamy coarse sand; single grain; when wet, very dark grayish brown.
8 to 29 inches, coarse sandy loam or loamy sand that is similar in color to, or slightly paler than, the layer above; slightly hard to soft; gravelly in lower part.
29 inches+, fairly loose porous gravelly loamy sand, somewhat similar in color to layer above; contains much gray and dark-gray sand and gravel.

The upper part of this soil was derived mainly from pumice sand, with which was mixed considerable gray and dark-gray sand and small pebbles. The lower layer consists mainly of the same kind of dark-colored sand and gravel, but in most places it contains considerable light-colored pumice sand. In some places the lower layer contains cobblestones. The darker colored material is water-laid outwash deposits, probably glacial outwash from the nearby mountains. This material was derived from andesite, basalt, and probably other rocks. The pebbles range from rounded to subangular. The texture of each layer varies somewhat from place to place.

Most of this soil is noncalcareous throughout. The reaction is about neutral, but the range is from slightly acid to mildly alkaline. The organic-matter content is rather low.

To show variations in slope, two phases of this soil are mapped.

Deschutes loamy coarse sand, over gravelly material, 0 to 3 percent (Dc).—This soil occurs in a few fairly extensive tracts northwest of Tumalo near Plainview. Runoff is very slow and water erosion is negligible. Drainage is rapid through the surface soil and subsoil and very rapid through the gravelly lower material. The water-holding capacity is low. The frost hazard is moderate to high. This soil is very easily worked, but its natural fertility is low.

Use and management (subgroup 1B).—This soil needs large amounts of irrigation water, but it occurs in an area where water is scarce in the summer. Nearly two-thirds of it has not been cultivated but is still under its natural cover of juniper, sagebrush, and grass. This acreage is used for range. The carrying capacity is low. About 20 percent of this soil has been cultivated but is now idle or in annual grasses or crested wheatgrass. The rest is irrigated and used for crops and pasture, or is used for farmsteads. The crops most commonly grown are small grains, potatoes, alsike clover for seed, vetch for seed, and other crops that do not need much irrigation late in summer.

Cropping practices and management needs for this soil are similar to those for Deschutes loamy sand, 0 to 3 percent slopes, but the need for water is greater. If irrigated, this soil is fair to good for crops; it is poorly suited to dry-farmed grains.

Deschutes loamy coarse sand, over gravelly material, 3 to 7 percent slopes (Dd).—This inextensive soil occupies a few small areas in association with Deschutes loamy coarse sand, over gravelly material, 0 to 3 percent slopes. This more strongly sloping soil is more likely to erode if irrigated; the irrigation water should be applied in short runs and should be carefully controlled. Nearly three-fourths of this soil remains under its natural cover, and part of the rest is idle. The soil is fair to poor for irrigated crops. It is in management subgroup 1E.

Deschutes loamy sand

Much of Deschutes loamy sand is near Bend, in the extreme southern part of the Area. Other tracts are near Cloverdale, Tumalo, and Terrebonne. This soil is coarser textured than Deschutes sandy loam in both the surface soil and the subsoil; the light yellowish-brown, very pale brown, or yellow pumice particles are more conspicuous in the Deschutes loamy sand, and the proportion of coarser particles is higher. Furthermore, this soil is less fertile than Deschutes sandy loam; it is lower in water-holding capacity and requires more water for irrigation.

Like Deschutes sandy loam, this soil developed principally from light-colored, lightweight pumice sand derived from volcanic material that erupted south and southwest of this Area. The pumice sand was 2 or 3 feet deep, but it has been moved by wind and water and is now uneven in depth. It has weathered somewhat, and a little organic matter has accumulated in the surface soil.

Deschutes loamy sand is somewhat excessively drained. Drainage through the soil is rapid; through the substratum it is generally moderate to very rapid. Runoff is very slow.

Typical profile:

0 to 15 inches, grayish-brown or light brownish-gray to brown or pale-brown loamy sand; contains a large amount of light yellowish-brown or very pale brown pumice particles; most particles range from medium to very coarse sand in size but a few are as large as 3/16 inch in diameter; soft or very friable to nearly loose; single grain; noncalcareous and mostly neutral but ranges from slightly acid to mildly alkaline; when moist, dark grayish brown or very dark grayish brown; lower part may be slightly browner than the plow layer.

15 to 26 inches, similar in color or slightly browner than layer above; somewhat hard heavy loamy sand or light sandy loam; contains pumice particles like layer above; breaks into weak subangular blocky or rounded aggregates or nodules ¼ to ¾ inch in diameter; aggregates are very slightly firm and moderately fine porous; noncalcareous and mostly mildly alkaline; when moist, dark grayish brown to dark brown or olive brown.

26 to 33 inches, similar to layer above but slightly calcareous; in places the lime is segregated in small veins.

33 inches +, in most places substratum is basalt bedrock. Where the substratum is not basalt bedrock it may be (1) more or less cemented gravelly or sandy material or sedimentary material of the Dalles formation (*5*); (2) pumice or volcanic cinders; or (3) loose gravel, cobblestones, or coarse sand. Commonly the basalt and the cemented materials have thin coatings of lime on their surfaces or in cracks.

Because of the large quantity of light-colored pumice, this soil, when dry, is lighter colored than is typical of the loamy sand in the profile. Small angular or subangular fragments or rounded pebbles of basalt or other rock are scattered through the soil in many places.

This soil is low in organic matter and nitrogen. Salts or alkali rarely occur in harmful quantities. Included are some areas where the surface soil is light sandy loam, coarse sandy loam, or loamy coarse sand.

To show variations in slope, erosion, stoniness, and the nature of the substratum, 13 phases of this soil are mapped.

Deschutes loamy sand, 0 to 3 percent slopes (De).—This extensive soil occupies most of the level and nearly level nonstony irrigated areas near Bend. It also occurs east and northeast of Bend between low ridges or knolls of Scabland.

The natural vegetation consists of fairly open stands of juniper, big sagebrush, rabbitbrush, bunchgrasses, cheatgrass, other annual grasses, and associated herbs. South and southeast of Bend, pines are mixed with the juniper and bitterbrush is an important part of the understory. In the moister areas there is some snowbrush and manzanita. Bitterbrush occurs with the sagebrush in a 2- to 4-mile belt just below the lower edge of the pines. In the places where pine and bitterbrush grow, the soil differs from a typical Deschutes soil in that it is generally noncalcareous throughout the profile. Most of this soil receives 10 to 13 inches of precipitation a year, but it has a shorter frost-free season than most of the Deschutes sandy loam.

Use and management (subgroup 1B).—This soil is fair to good for crops. It is used in about the same way as Deschutes sandy loam, 0 to 3 percent slopes, except that a larger proportion of it is in native range and a larger proportion is used to grow wheat. The management requirements of the two soils are similar, but this soil requires more water and more frequent irrigation. The head of water should be larger and the irrigation runs shorter. This soil also needs more fertilizer and organic matter than Deschutes sandy loam, 0 to 3 percent slopes. Crops on this soil are more likely to be damaged by frosts. Average yields are 25 to 40 percent less.

Deschutes loamy sand, 3 to 7 percent slopes (Dg).—This soil is like the associated Deschutes loamy sand, 0 to 3 percent slopes, except that, because of the gentle slopes, the erosion hazard under irrigation is moderate to somewhat high. Included in the mapping unit are about 40 acres that have been moderately sheet eroded. These areas are identified on the soil map by erosion symbols.

Use and management (subgroup 1E).—This soil is somewhat similar to Deschutes.sandy loam, 3 to 7 percent slopes, in use and management, but a greater part is under natural cover and a greater part is used for wheat. Furthermore, this soil needs more water and more frequent irrigation than the sandy loam. The head of water should be larger and irrigation runs shorter. This soil also needs large additions of organic matter and large annual applications of fertilizer. The eroded areas need slightly more organic matter and nitrogen than the uneroded soil.

This soil is poor to fair for crops. It is not suitable for dry-farmed grain. It should be kept in hay and pasture as much as possible. A straw mulch helps keep the soil from blowing and washing while new stands of hay or pasture are being established. Average yields are slightly less than on Deschutes sandy loam, 3 to 7 percent slopes.

Deschutes loamy sand, 7 to 12 percent slopes (Dh).—This soil is moderately sloping or rolling. It is highly erosive under irrigation.

Use and management (Subgroup 1H).—This soil is poorly suited to row crops. Much of it is in its natural vegetation. Irrigated areas should be kept in alfalfa-grass or clover-grass hay or in grass-legume pasture most of the time. The productivity is low. Grain can be seeded lightly when it is necessary to re-establish a pasture stand. A straw mulch should be used until the new stand is established, to keep the soil from blowing and washing.

Irrigation water should be carefully controlled. The head should be fairly large and runs should be short. This soil can be irrigated by the corrugation method or by flooding from contour laterals.

Deschutes loamy sand, eroded, 0 to 3 percent slopes (Df).—This soil occurs in scattered areas in Deschutes County. It is moderately eroded; 2 or more inches of the original topsoil has been removed by wind. This soil contains less organic matter and nitrogen and is slightly shallower than Deschutes loamy sand, 0 to 3 percent slopes.

Use and management (subgroup 1B).—Nearly all of this soil is in natural vegetation; only about 7 percent is cultivated. It is similar in management needs and crop suitability to Deschutes loamy sand, 0 to 3 percent slopes, but needs more organic matter and nitrogen.

Deschutes loamy sand, over cinders, 0 to 3 percent slopes (Dk).—Most of this inextensive soil occurs near Terrebonne. Its surface soil and subsoil are similar to those of Deschutes loamy sand, 0 to 3 percent slopes. At depths between 16 and 36 inches, however, this soil is underlain by cindery or pumicy material similar to that underlying Deschutes sandy loam, over cinders, 0 to 3 percent slopes. This substratum commonly is mantled with a very thin layer of lime, or it may contain lime in cracks or veins. In places the subsoil contains some cinders. The cinders and pumice are generally loose and very porous; water drains downward through them very rapidly. In places, however, the material is more or less cemented; in such places it impedes root penetration and probably retards the movement of water.

Use and management (subgroup 1B).—This soil is used and managed in about the same way as Deschutes loamy sand, 0 to 3 percent slopes, but because the substratum is generally more porous, it requires more irrigation water.

Deschutes loamy sand, over cinders, 3 to 7 percent slopes (Dl).—This soil occurs in several scattered areas near Terrebonne. It is similar to Deschutes loamy sand, over cinders, 0 to 3 percent slopes, but because of the stronger slopes it is more likely to erode under irrigation. The water-holding capacity is low.

Use and management (subgroup 1E).—About 90 percent of this soil is under the natural vegetation of sagebrush, grass, and juniper, which furnishes poor grazing. Most of the rest is irrigated for crops and pasture.

This soil is only fair to poor for irrigated crops. If possible, it should be kept in pasture or hay. A straw mulch helps to keep the soil from blowing and washing while a new stand is being established. Unless it is irrigated, this soil is not suited to small grains.

Because of runoff and the rapid movement of water through the soil, it is difficult to distribute water evenly and keep erosion at a minimum. Water should be applied frequently. The most suitable method of irrigation is flooding from contour laterals or the use of corrugations. A large head of water should be used.

Deschutes loamy sand, over cinders, eroded, 3 to 7 percent slopes (Dm).—This soil occurs in a few small scattered areas near Terrebonne. It is moderately eroded by water or wind.

Use and management (subgroup 1E).—Most of this soil is used for irrigated crops and pasture. Crop suitability and management needs are similar to those of Deschutes loamy sand, over cinders, 3 to 7 percent slopes.

Deschutes loamy sand, over cobbly material, 0 to 3 percent slopes (Dn).—This inextensive soil occurs on a few rather low, nearly level terraces along the Deschutes River in Deschutes County. The largest area is near Tumalo. Except that it contains a small to moderate number of rounded pebbles, the upper part of this soil is similar to the upper part of Deschutes loamy sand, 0 to 3 percent slopes. Instead of basalt bedrock, the substratum below depths of 2 to 3 feet consists of loose rounded pebbles and cobblestones, a few rounded boulders up to 4 feet in diameter, and very little fine material. The water-holding capacity of this soil is low. Drainage is rapid through the upper part of the profile and very rapid through the substratum.

Use and management (subgroup 1B).—This soil is fair for irrigated crops. It is used and managed in about the same way as Deschutes loamy sand, 0 to 3 percent slopes, but it needs more water and more frequent irrigation. Average yields are slightly less. A few acres are used for gravel pits.

Deschutes loamy sand, over gravelly material, 0 to 3 percent slopes (Do).—This soil occurs on the outwash plain in Deschutes County west of the Deschutes River. Most of it is near Plainview. Some areas are extensive.

The natural vegetation on most of this soil consists of juniper, big sagebrush, and grasses, but at the extreme western edge of the Area some ponderosa pines are mixed with junipers and some bitterbrush is mixed with sagebrush.

The upper part of this soil was derived mainly from pumice, but the substratum and the coarser particles throughout the soil apparently are outwash from the Cascade Mountains, perhaps glacial outwash. Included are areas that have a sandy loam surface soil. In places the subsoil is sandy loam, gravelly loam, or loam.

This soil is similar to Deschutes loamy sand, 0 to 3 percent slopes, except for the following: (1) In many places this soil is noncalcareous throughout; (2) instead of angular fragments of basalt, the surface soil contains scattered rounded pebbles, and the subsoil contains a few scattered pebbles or many pebbles and small cobblestones; (3) below depths of 25 to 40 inches, the subsoil grades into somewhat loose or very friable cobbly sandy loam or loamy sand. The pebbles and cobblestones, which are as much as 4 or 5 inches in diameter, are rounded or subangular. They were derived from dark-colored lava rock.

The water-holding capacity of this soil is rather low, but it is slightly higher than that of the associated Deschutes coarse sandy loam, over sandy material, and Deschutes loamy coarse sand, over gravelly material.

Use and management (subgroup 1B).—Between 35 and 50 percent of this soil is under natural cover, and 5 to 10 percent that was formerly cultivated is used for range. Under irrigation, this soil is good to fair for crops, but much of it is not irrigated, chiefly because of the scarcity of water in the Squaw Creek irrigation district during the summer.

This soil is used in about the same way as Deschutes loamy sand, 0 to 3 percent slopes. It has similar management requirements and produces about the same yields. Because the growing season is short, this soil is only moderately well suited to potatoes, and average yields of potatoes are rather low. Most of the grain is planted in spring. If enough water is available, this soil is well suited to alfalfa, clover for seed, and vetch for seed. A small acreage is used to grow rye without irrigation. Yields of rye are normally 7 to 10 bushels.

Deschutes loamy sand, over gravelly material, 3 to 7 percent slopes (Dp).—This soil is gently sloping or undulating. It is more likely to erode under irrigation than Deschutes loamy sand, over gravelly material, 0 to 3 percent slopes.

Use and management (subgroup 1E).—About two-thirds of this soil is under natural vegetation. Most of the rest is used for irrigated crops and pasture. Some of this soil is irrigated by flooding from contour laterals. Yields are somewhat lower than on Deschutes loamy sand, over gravelly materials, 0 to 3 percent slopes.

This soil is fair for irrigated pasture, hay, and small grains. It should be kept in these crops as much of the time as possible. Irrigation water must be carefully applied to avoid causing erosion. This soil is not suited to row crops.

Deschutes loamy sand, over semicemented sandy material, 0 to 3 percent slopes (Dr).—This nearly level soil occurs in the outwash plains, in the west-central part of the mapped area of Deschutes County. Part of it occurs where irrigation water is scarce late in summer. Because of its coarser texture, this soil has lower water-holding capacity than Deschutes sandy loam, over semicemented sandy material, 0 to 3 percent slopes.

The surface soil and subsoil are similar to those of Deschutes loamy sand, 0 to 3 percent slopes, but they commonly contain somewhat larger quantities of rounded or subangular small pebbles. In some areas larger pebbles are numerous in the subsoil, and in some areas the entire subsoil is noncalcareous.

At depths of about 25 to 35 inches, the loamy sand or sandy loam subsoil is underlain by weakly to strongly cemented sandy material that is mixed in many places with pebbles or pebbles and cobblestones. This cemented layer commonly contains much lime. In places, however, it is noncalcareous and apparently is cemented by silica or siliceous material. This layer does not appear to be a continuous, strongly cemented, impermeable hardpan over wide areas. It apparently has fissures and also many weakly cemented spots that are more or less permeable. Although much of the layer can be broken with the hands, some of it cannot. The cemented layer ranges from 1 to 12 inches in thickness, and it may consist of two or more discontinuous strata.

Loose sand underlies the cemented layer. In many places the sand contains gravel and cobblestones. This material originated mainly from andesite and basalt. It seems to be water-spread outwash from the nearby mountains, probably glacial outwash.

Runoff is very slow, and the erosion hazard under irrigation is slight. Drainage through the soil to the cemented layer is rapid. Drainage is slow through the cemented layer and very rapid through the underlying sand and gravel.

Use and management (subgroup 1B).—About half of this soil is under its natural vegetation of juniper, sagebrush, rabbitbrush, grass, and associated herbs. Less than one-fourth is irrigated and used for crops and pasture. The rest was formerly cultivated, but it is now idle or in cheatgrass or crested wheatgrass. A few acres are used for gravel pits.

This soil is similar to Deschutes loamy sand, 0 to 3 percent slopes, in use suitability, productivity, and management needs, but its subsoil is less likely to become waterlogged from overirrigation.

Deschutes loamy sand, over semicemented sandy material, 3 to 7 percent slopes (Ds).—This soil is gently sloping or undulating. It is slightly difficult to irrigate without causing erosion. Erosion is negligible or slight in unirrigated areas.

Use and management (subgroup 1E).—About 70 percent of this soil is under its natural vegetation of juniper, sagebrush, and grass. Most of the rest is irrigated for crops and pasture, but some areas occur where irrigation water is scarce late in summer. The principal crops are alfalfa, oats, barley, wheat, alsike clover for seed, and potatoes. Average yields are lower than on Deschutes loamy sand, over semicemented sandy material, 0 to 3 percent slopes.

This soil can be irrigated satisfactorily either by flooding from contour laterals or by using corrugations. Water should be applied under careful control. Short runs and a large head should be used.

If cultivated, this soil needs heavy additions of organic matter and large annual applications of fertilizer. The soil is fair to poor for crops. If possible, it should be kept in pasture or hay. While a stand is being reestablished, a straw mulch helps to keep the soil from blowing and washing. This soil is not suited to dry-farmed grain.

Deschutes loamy sand, over semicemented sandy material, 7 to 12 percent slopes (Dt).—This inextensive soil occupies a few scattered tracts near Tumalo. About 80 percent is in the natural vegetation, and only a few acres are irrigated. This soil is poorly suited to row crops. It is similar in use suitability and management needs to Deschutes loamy sand, 7 to 12 percent slopes. It is in management subgroup 1H.

Deschutes sandy loam

Deschutes sandy loam is the most extensive soil in the Area. It occupies a large part of the acreage south of the Crooked River. In the areas near Bend, the soil is coarser textured than is typical. Only a small acreage of this soil occurs north of the Crooked River.

Much of Deschutes sandy loam occurs in small swalelike areas that are nearly level or gently sloping. These areas lie between the mounds and ridges of outcropping lava (Scabland) which are characteristic of much of the upland plain in Deschutes County. Other areas lie on the nearly level outwash plain west of the Deschutes River. Some areas have slopes of as much as 20 percent gradient.

Most of this soil receives 8 to 11 inches of precipitation annually. In these semiarid areas the natural vegetation consists mainly of open stands of juniper with an understory of big sagebrush, bunchgrasses, annual grasses, rabbitbrush, and herbs. On small acreages in the extreme southern and western parts of the Area, which receive a little more precipitation, the natural vegetation includes some ponderosa pine and bitterbrush.

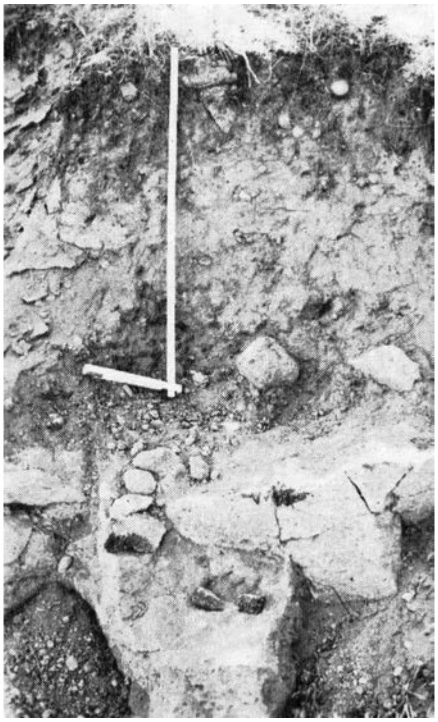

Figure 2.—**Cut in Deschutes sandy loam, 0 to 3 percent slopes, just west of Redmond. The upper part of this soil was derived mainly from pumice, and it overlies lime-coated basalt. This is the most extensively irrigated soil in Deschutes County.**

This soil developed mainly from pumice sand, which apparently was weathered from material that erupted from now-extinct volcanoes south and southwest of the Area. The pumice sand, possibly mixed with a little fine volcanic dust, was carried northward by the wind. The deposits were reworked by wind and water, which moved material from the higher spots and redeposited it in low places, so that the layer of pumice sand is now of uneven thickness. In general, the layer becomes thicker and the texture of the material coarser toward the south and southwest; that is, in the direction of the extinct volcanoes. The lower part of this soil may be mixed with fragments of basalt, pebbles washed from nearby ridges of Scabland, or gravelly or sandy materials from other sources.

Deschutes sandy loam normally has a slightly developed profile; the subsoil is slightly finer textured and more compact than the surface soil and has only weakly developed structural aggregates. This soil differs from the associated Redmond soils in having a less developed and coarser textured subsoil. It is better drained than the Odin soils. It differs from the somewhat similar Era soils mainly in that it was derived from materials that contained more pumice. Figure 2 shows a profile of Deschutes sandy loam, 0 to 3 percent slopes.

Typical profile:

0 to 13 inches, grayish-brown or light brownish-gray to brown or pale-brown soft sandy loam; layer mainly light yellowish-brown or pale-brown pumice particles, most of them ranging in size from medium to very coarse sand; noncalcareous and mostly neutral in reaction but ranges from slightly acid to mildly alkaline; when moist, dark grayish brown or very dark grayish brown and very friable; lower part may be slightly browner than the plow layer.

13 to 22 inches, pale-brown or light yellowish-brown, grading toward light brownish-gray or grayish-brown, sandy loam or heavy sandy loam; slightly lighter in color and browner than layer above; hard and firm but breaks with moderate pressure of hands into weak subangular or rounded aggregates that range from ¼ to ¾ inch in diameter; slightly dense but somewhat porous; noncalcareous and mostly mildly alkaline; contains pumice sand ranging from the size of medium sand to that of coarse sand; when moist, dark grayish brown to dark brown or olive brown.

22 to 30 inches, material similar to that in layer above but slightly calcareous; in places lime is segregated in small veins.

30 inches +, in most places substratum consists of basalt bedrock.

In places, the texture is a fine sandy loam. Included in the mapping unit are some soils that are entirely noncalcareous.

In some places the substratum is (1) gravelly or sandy material or sedimentary material of the Dalles formation, more or less cemented with lime and silica (*5*); (2) volcanic pumice or cinders; or (3) in many of the areas west of the Deschutes River, loose gravel, coarse sand, or cobblestones. A thin coating of lime commonly overlies the basalt and the cemented materials.

This soil contains a considerable to a large quantity of light yellowish-brown, very pale brown, or yellow pumice the size of fine to very coarse sand. The pumice tends to accumulate in miniature depressions and imparts to the surface of the dry soil a color that is browner than is typical of the finer material in the surface layer. In many places scattered small angular or subangular fragments or rounded pebbles of basalt or other igneous rock occur throughout the soil.

This soil is relatively low in organic matter and nitrogen. Salts or alkali do not normally occur in injurious quantities. This soil is well drained. Above the substratum it is moderately to rapidly permeable to water, roots, and air. The substratum varies greatly in permeability. Runoff generally is slow or very slow.

To show variations in slope, erosion, stoniness, depth to substratum, kind of substratum, and moisture relations, 26 phases of this soil are mapped.

Deschutes sandy loam, 0 to 3 percent slopes (Du).—This is the largest mapping unit of Deschutes sandy loam in the Area. It occurs in level or nearly level areas where erosion is negligible or slight. A few areas have been moderately eroded by water or wind. Most of this soil occurs in low areas between ridges or mounds of Scabland on the upland plain in Deschutes County, east of the Deschutes River and north of Bend.

The substratum varies from place to place. Typically, it is basalt, commonly more or less vesicular and fissured. In places, however, it consists of sedimentary material of the Dalles formation (*5*) or other water-transported materials, or of cemented or semiconsolidated sand, gravel, and agglomerate. In many places, the basalt or semiconsolidated material has a thin coating of lime. Some angular basalt fragments commonly lie above the basalt bedrock. In most places, movement of water through the substratum is somewhat slow but, unless too much irrigation water is applied, drainage is adequate. The penetration of roots, water, and air through the surface soil and subsoil is moderate to rapid. In a few swales, however, the substratum is impermeable or slowly permeable. In these places the subsoil and even the entire profile may become waterlogged by excess irrigation water or by runoff from higher areas. The depth to the substratum ranges from 16 to 36 inches.

This soil apparently is moderately fertile, but it is low in organic matter and nitrogen. It responds to good management, however, and it is very easily tilled. If water is available this soil is easy to irrigate. The erosion hazard under irrigation is slight.

Use and management (subgroup 1A).—Three-fourths or more of this soil is used for irrigated crops and pasture. Almost all of the rest is under the natural vegetation. Much of the nonirrigated soil lies in relatively small, unconnected areas in the eastern part of the Area south and east of Redmond. Smaller nonirrigated tracts occur on irrigated farms, in places that cannot conveniently be irrigated. Little of this soil is idle and practically none of it is dry-farmed. It is poorly suited to dry farming.

Systematic crop rotations are not practiced on most farms but some general crop sequences are common. Alfalfa, the principal crop, is grown for 5 to 7 years or until it becomes grassy or low in yield. On most farms potatoes follow alfalfa, clover, or pasture. Potatoes are often grown a second year, and then followed by oats, barley, wheat, or rye. Generally, alfalfa is seeded again in the grain stubble. If potatoes are not grown, grain commonly follows alfalfa, clover, or pasture. Typical irrigated pastures consist primarily of bluegrass and whiteclover. Rotation pastures are not common.

Clover grown for seed may be sown in the grain stubble in place of the alfalfa. Unless weeds become too dense, two seed crops are usually obtained from alsike clover and Ladino clover. Because it is difficult to keep Ladino clover free from other clovers and weeds, not much Ladino clover is grown for seed on this soil. Some red clover is grown for hay and seed. On a few farms vetch is grown for seed, often in a 2-year rotation with oats and barley.

Potatoes are usually fertilized with about 300 pounds of 6–10–4 fertilizer an acre the first year. If potatoes are grown a second year, a slightly larger application of fertilizer is generally used, but no fertilizer is used on oats, barley, wheat, or rye when they follow potatoes. All available manure is used on potatoes, other row crops, or grain. On most of the farms pastures are not fertilized.

If irrigated, this soil is moderately well suited to a wide range of crops and very well suited to potatoes. Potatoes are irrigated by the furrow method, and legumes, grain, and pasture by the strip-border method. No special practices for erosion control are generally used. The potatoes form well-shaped tubers in this moderately coarse textured soil. They are practically free of dirt when dug, and they need little or no brushing to make them bright and clean for market. Because this soil is only moderately deep, it has limited water-holding capacity and is not well suited to alfalfa and other deep-rooted crops.

This soil needs to be managed in such a way as to build up its supply of organic matter. Effective management practices are described in the section, Use and Management of Soils, and in several publications of the Oregon Agricultural Experiment Station (*10*) (*12*) (*11*) and other agencies (*14*).

Fertilizer trials on Deschutes sandy loam, 0 to 3 percent slopes, have shown that (1) sulfur is the element most needed for legumes; (2) potassium fertilizers help potatoes, legumes, and possibly other intensively grown crops; and (3) nitrogen is needed by many crops (*9*) (*10*). Much of the nitrogen can be supplied by plowing under a good growth of well-inoculated legumes. Ammonium sulfate or some other nitrogen fertilizer helps grains that do not follow a legume or fertilized crop. Phosphorus appears to benefit potatoes, pasture, and legumes, especially seed legumes. A little boron applied to potatoes seems to result in smoother, better shaped tubers.

Farmers who consistently obtain high yields apply from 30 to 50 pounds of sulfur, preferably in the form of gypsum, to alfalfa every year. For pasture and for most other legumes except hairy vetch, they apply gypsum every 2 years. Alfalfa and other legumes also receive treble phosphate or an equivalent quantity of phosphorus in superphosphate. Sulfur is not commonly used on vetch planted for seed, because it is likely to stimulate growth enough to make the crop difficult to harvest. Potatoes receive fairly heavy applications of a complete fertilizer. If potatoes are grown in 2 successive years, rye or some other green-manure crop is usually plowed under before the second crop, and manure or ammonium sulfate is added. Fertilizers are seldom used on grains that follow legumes or heavily fertilized potatoes, but grains that do not follow legumes or fertilized potatoes ordinarily are fertilized with nitrogen and phosphate.

Farmers who obtain high yields use good irrigation practices, including proper land leveling, the efficient layout of field ditches with checks and drops where needed, and the timely use of water.

Deschutes sandy loam, 3 to 7 percent slopes (Dv).—This soil is like Deschutes sandy loam, 0 to 3 percent slopes, but because it is gently sloping it is more likely to erode if irrigated. Most of the irrigated areas are slightly eroded. Only a small acreage has lost more than one-fourth of the original surface soil. A few shallow gullies have formed. This soil is slightly shallower than Deschutes sandy loam, 0 to 3 percent slopes.

Use and management (subgroup 1D).—This soil is used in much the same way as Deschutes sandy loam, 0 to 3 percent slopes. Average yields are slightly less, however, and because of the erosion hazard, a somewhat smaller part of this soil is used for potatoes, and a larger part is used for alfalfa and pasture.

This soil is easy to till. It is somewhat less suitable than Deschutes sandy loam, 0 to 3 percent slopes, for potatoes and other row crops. It should be kept in alfalfa, clover, or pasture two-thirds to three-fourths of the time, if possible. Additions of organic matter would help to prevent erosion, increase the productivity of the soil, and improve the water-holding capacity. Smooth bromegrass, big bluegrass, or other grasses, grown with the alfalfa for hay, will also help to prevent erosion (*10*).

Irrigation water should be applied carefully. The gently sloping areas can be irrigated by the strip-border method. Unless the strips are carefully graded and leveled between the borders, the corrugation method may be more effective on the stronger slopes. The strips should be narrower and the runs shorter than on Deschutes sandy loam, 0 to 3 percent slopes. Flooding from contour laterals may be suitable in some areas.

Deschutes sandy loam, 7 to 12 percent slopes (Dw).—This inextensive soil occurs mostly in the northern part of Deschutes County. It is associated with other phases of Deschutes sandy loam. It is slightly more shallow than Deschutes sandy loam, 0 to 3 percent slopes.

Use and management (subgroup 1G).—About 80 percent of this soil is in its natural vegetation of sagebrush, juniper, and grass. The carrying capacity is very low. Approximately 10 percent was formerly cropped, but this acreage is now idle or is in grass and used for grazing. About 10 percent is irrigated.

This soil is poorly suited to row crops. It should be kept most of the time in alfalfa-grass or clover-grass hay or in grass-legume pasture. A light seeding of oats or barley should be used to reestablish a stand. Clover can be grown for seed. This soil is very poorly suited to dry-farmed grains, and practically none of it is used for these crops. It is less productive than more nearly level Deschutes sandy loams.

Under irrigation, this soil is used in somewhat the same way as Deschutes sandy loam, 0 to 3 percent slopes, but a larger part of its irrigated acreage is used for alfalfa and pasture. It is more difficult to work and much more difficult to irrigate than Deschutes sandy loam, 0 to 3 percent slopes.

Irrigation water should be very carefully controlled, and runs should be short. The corrugation method, with a small head of water, may be the best way of irrigating this soil. Flooding from contour laterals, however, may be effective.

Deschutes sandy loam, 12 to 20 percent slopes (Dy).—Except that this soil is more shallow and varies more from place to place, it is similar to Deschutes sandy loam, 0 to 3 percent slopes. Because of the strong or moderately steep slopes, water is very difficult to control and the erosion hazard is very high.

About one-third of this mapping unit consists of areas in which the surface soil is a loamy sand. Some of these areas have slopes of more than 20 percent. Almost one-third of this soil has enough stones on the surface and in the surface soil to interfere with cultivation. These areas are identified on the map by stone symbols. About one-fourth of this soil is moderately sheet eroded. In a few places gullies have formed; some cannot be crossed by farm machinery.

Use and management (subgroup 1I).—This soil is very poor for crops under irrigation; it is generally better suited to range grazing. A considerable part of it is under the natural vegetation. Under very careful management, some of the less steep areas can be used for irrigated grass-legume pasture. This soil is very poor for dry-farmed grains.

Grass-legume pasture can be irrigated by corrugations running down the steepest slopes. The water should be supplied in short runs under a well-controlled head.

Most of the areas used for range can be improved by seeding crested wheatgrass mixed with bulbous bluegrass, beardless wheatgrass, and bluebunch wheatgrass. The range can be plowed or disked in the spring, left fallow in summer, and seeded with a drill in fall. New stands of grass should not be grazed the first year, and established stands should be protected from overgrazing.

Deschutes sandy loam, deep, 0 to 3 percent slopes (Dz).—This soil occurs in many scattered areas in Deschutes County. Many tracts are in low, level spots or shallow swales between ridges of Scabland or within broader tracts of shallower Deschutes soils. In some of the swales excessive irrigation and runoff from higher land may cause waterlogging of the subsoil and, eventually, some accumulation of soluble salts.

This soil is deeper than the associated Deschutes sandy loam, 0 to 3 percent slopes, and has better water-holding capacity. In most places it is 36 or more inches in depth to the basalt bedrock, semiconsolidated material, or other layer that is impermeable to roots.

Use and management (subgroup 1A).—This soil is somewhat similar in use suitability and management needs to Deschutes sandy loam, 0 to 3 percent slopes, but it is better suited to alfalfa and other deep-rooted crops. Yields, particularly of alfalfa, red clover, and alsike clover, tend to be higher on this soil. Irrigation water can be applied in larger quantities and less frequently on this soil, and deeper cuts can be made when leveling. This is one of the better soils of the Area for many crops.

Deschutes sandy loam, deep, 3 to 7 percent slopes (Dea).—This soil is similar to the associated Deschutes sandy loam, 3 to 7 percent slopes, except that it is 36 inches or more in depth to the basalt bedrock, semiconsolidated sedimentary material, or other material that roots cannot penetrate. Because it is deeper, this soil has better water-holding capacity. Small areas of moderately eroded soil are included; in a few places gullies occur.

Use and management (subgroup 1D).—Except that it is better suited to alfalfa and other deep-rooted crops, this soil is similar to Deschutes sandy loam, 3 to 7 percent slopes, in present use, suitability for use, and management needs. Average yields, particularly of alfalfa, red clover, and alsike clover, are higher on this deep soil. Irrigation water can be applied in larger quantities and at longer intervals. The eroded areas require larger additions of organic matter than the noneroded areas and also need somewhat heavier applications of manure and fertilizer.

Deschutes sandy loam, deep over cinders, 0 to 3 percent slopes (Deb).—Most of this inextensive soil occurs west of Terrebonne. It overlies a substratum of volcanic cinders or pumicy material similar to those in the substratum of Deschutes sandy loam, over cinders, 0 to 3 percent slopes. In most places this soil is 36 inches or more in depth to the cindery substratum.

Use and management (subgroup 1A).—This soil is similar to Deschutes sandy loam, deep, 0 to 3 percent slopes, in use, management, and yields, but it probably needs slightly more water at slightly shorter intervals. This is one of the better soils of the Area for irrigated crops.

Deschutes sandy loam, eroded, 7 to 12 percent slopes (Dx).—This soil occurs in a few scattered tracts. It is moderately eroded; about one-fourth to three-fourths of the original topsoil, or plow layer, has been removed, mainly by sheet erosion. Gullies have formed in a few places. This soil is 2 to 5 inches shallower than Deschutes sandy loam, 7 to 12 percent slopes, and is also slightly lower in organic matter and nitrogen.

Use and management (subgroup 1G).—About 30 percent of this soil is irrigated and used for crops or pasture. The rest is under a cover of juniper, sagebrush, and grass. Use suitability and management needs are similar to those of Deschutes sandy loam, 7 to 12 percent slopes, except that the need for organic matter and nitrogen is greater.

Deschutes sandy loam, over cinders, 0 to 3 percent slopes (Dec).—Most of this soil occurs in the northern part of Deschutes County west of Terrebonne (fig. 3). It is similar to Deschutes sandy loam, 0 to 3 percent slopes, but instead of being underlain by basalt or semiconsolidated sedimentary material, it is underlain by a substratum of reddish-brown, red, dark-red, black, pale-gray, or yellow vesicular or spongelike volcanic cinders, pumice, or pumiceous materials. In many places the cindery substratum is porous; in other places it ranges from weakly cemented to strongly cemented. It is not practicable to delineate these variations on the soil map. Little or no lime may occur where the substratum is loose, but where the substratum is more or less cemented, the lower part of the subsoil commonly is calcareous, and the substratum is lime-coated or contains lime in fissures or veins. Where the underlying cinders are loose and excessively porous, drainage through the substratum is very rapid; consequently, these areas require more water for irrigation than Deschutes sandy loam, 0 to 3 percent slopes, which has a substratum of basalt or semiconsolidated material that retards internal drainage.

Included in this mapping unit are a few acres from which much of the surface soil has been removed by wind. A few acres have enough basaltic stones on the surface and in the surface soil to interfere with tillage; these areas are shown on the map by stone symbols. If the stones are removed from these areas, the soil is similar to the nonstony Deschutes sandy loam, over cinders, 0 to 3 percent slopes.

Use and management (subgroup 1A).—Except that somewhat more water is required and that water must be applied more frequently, this soil is similar to Deschutes sandy loam, 0 to 3 percent slopes, in present use, suitability for use, and management needs. Places where the underlying cinders are excessively loose and porous need heavier and more frequent irrigation. Average yields are slightly less than on Deschutes sandy loam, 0 to 3 percent slopes, but this soil seems to be better suited to alfalfa because it has better underdrainage. The eroded areas of this soil need large amounts of organic matter and fertilizer.

Deschutes sandy loam, over cinders, 3 to 7 percent slopes (Ded).—This soil occurs near Terrebonne. Except that it is gently sloping and is moderately erodible under irrigation, this soil is similar to Deschutes sandy loam, over cinders, 0 to 3 percent slopes.

Use and management (subgroup 1D).—In present use, suitability for use, and management needs this soil is similar to Deschutes sandy loam, 3 to 7 percent slopes, but apparently it needs more water and more frequent irrigation. It yields slightly less.

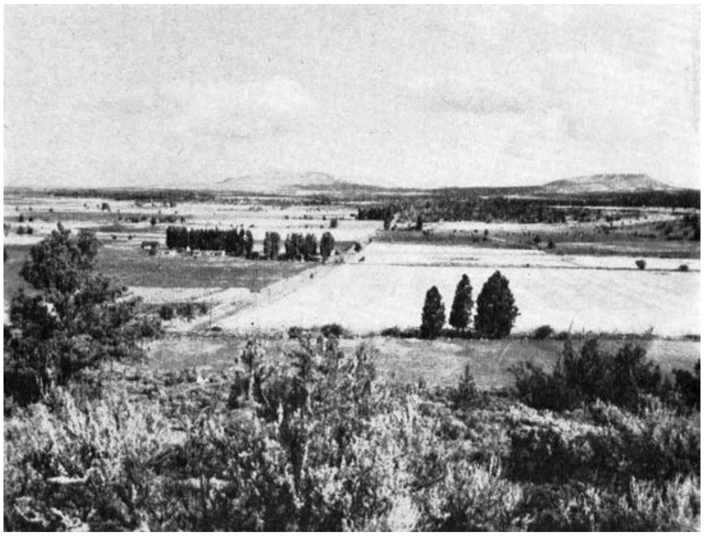

Figure 3.—**An area west of Terrebonne as seen looking northward from Tetherow Butte. Much of the irrigated crop area is Deschutes sandy loam, over cinders, 0 to 3 percent slopes. Big sagebrush and junipers on Rough stony land in foreground; Juniper Butte and Haystack Butte in distance.**

Deschutes sandy loam, over cinders, eroded, 3 to 7 percent slopes (Del).—This inextensive soil occurs in a few tracts near Terrebonne. It is moderately eroded. From 25 to 75 percent of the original topsoil has been removed from much of the area, and a few gullies have formed.

Use and management (subgroup 1D).—Most of this soil is irrigated and used for crops and pasture. It is similar in use suitability and management needs to Deschutes sandy loam, 3 to 7 percent slopes, but it is slightly less productive and apparently needs more water and more frequent applications of water. Organic matter is especially needed, and heavy applications of manure and fertilizer are suggested.

Deschutes sandy loam, over semicemented sandy material, 0 to 3 percent slopes (Deo).—This soil occurs extensively in the west-central part of the surveyed area of Deschutes County. It occurs in many areas on the nearly level to gently undulating outwash plains, particularly in the vicinity of Tumalo. It is farther west than most of Deschutes sandy loam, 0 to 3 percent slopes, and receives slightly more rain and may have a slightly shorter growing season.

The surface soil and subsoil are similar to those of Deschutes sandy loam, 0 to 3 percent slopes, but in some areas the subsoil is entirely noncalcareous or only slightly calcareous in the lower part. Furthermore, both the surface soil and subsoil in most places contain rounded or subangular pebbles that are scattered or grouped in small quantities. Most of the pebbles are less than 1 inch in diameter, but in some areas the pebbles in the subsoil are somewhat larger and fairly numerous.

At depths of about 28 to 35 inches, the subsoil is underlain by a weakly to strongly cemented layer consisting of sandy material mixed, in many places, with pebbles or pebbles and cobblestones. This layer is from 1 to 12 inches thick, and it may consist of two or more discontinuous cemented strata. In most places this layer, or hardpan, contains much lime, but in some places it is noncalcareous and apparently is cemented by silica or siliceous material. Much of this material can be broken in the hands, but some of it cannot. Where strongly cemented it has on the upper side a very thin, very dense or glazed coating that roots cannot penetrate. The hardpan, however, does not appear to be a continuous, strongly cemented, impermeable stratum. Apparently, there are fissures and also many places where the cementation is weak.

The cemented layer overlies coarse or very coarse loose sand, which in many places contains gravel and cobblestones. This underlying material was derived mostly from andesitic, basaltic, or other dark-colored, fine-grained, igneous rock. It appears to be waterspread outwash from the Cascade Mountains, probably glacial outwash.

Runoff from rainfall is low, and the erosion hazard under irrigation is slight. Drainage through the soil to the cemented layer is moderate to rapid; through the cemented layer it is slow; and through the underlying material it is very rapid. No drainage problem has developed under irrigation.

Use and management (subgroup 1A).—In present use, suitability for use, productivity, and management needs, this soil is similar to Deschutes sandy loam, 0 to 3 percent slopes. Its subsoil is less likely to become waterlogged. Oats are grown more extensively on this soil than on Deschutes sandy loam, 0 to 3 percent slopes. A few acres of this soil are used for gravel pits.

Deschutes sandy loam, over semicemented sandy material, 3 to 7 percent slopes (Des).—This soil occurs near Tumalo in the west-central part of the surveyed area of Deschutes County. It lies west of most areas of Deschutes sandy loam, 3 to 7 percent slopes, receives slightly more rainfall, and has a shorter growing season. It is similar to the associated Deschutes sandy loam, over semicemented sandy material, 0 to 3 percent slopes, but because it has stronger slopes it is more likely to erode under irrigation. The layer of semicemented material is at depths of 2 to 3 feet. It is similar to the hardpan that underlies Deschutes sandy loam, over semicemented sandy material, 0 to 3 percent slopes, but is generally somewhat less hard and more permeable.

Use and management (subgroup 1D).—About 58 percent of this soil remains under its natural vegetation of juniper, sagebrush, and grass, and is used for grazing. About 37 percent is used for irrigated crops or pasture. Oats is an important crop, but barley, wheat, alfalfa, potatoes, red clover, alsike clover, and vetch are also grown. This soil is similar in productivity, use suitability, and management needs to Deschutes sandy loam, 3 to 7 percent slopes.

Deschutes sandy loam, over semicemented sandy material, 7 to 12 percent slopes. (Dla).—This sloping or rolling soil occurs in several small scattered tracts near Tumalo. Its hardpan is somewhat less strongly cemented and more permeable than that of Deschutes sandy loam, over semicemented sandy material, 0 to 3 percent slopes. The erosion hazard under irrigation is high.

Use and management (subgroup 1G).—Nearly 85 percent of this soil is under the natural vegetation; a few acres have been planted to crested wheatgrass. A very small part is irrigated and used for crops and pasture. In use suitability and management needs this soil is similar to Deschutes sandy loam, 7 to 12 percent slopes.

Deschutes sandy loam, over semicemented sandy material, eroded, 12 to 20 percent slopes (Dlb).—This strongly sloping or hilly soil occurs in a few small tracts near Tumalo. About three-fourths of the acreage has lost 25 percent or more of the original topsoil through erosion, chiefly sheet erosion. In places, as much as 75 percent has been removed. The surface soil is thinner than that of Deschutes sandy loam, over semicemented sandy material, 0 to 3 percent slopes, and the hardpan is less strongly cemented and more permeable. It is very difficult to irrigate this soil without causing further erosion.

Use and management (subgroup 1I).—Nearly half of this soil is under a cover of juniper, sagebrush, and grass. Most of the rest is irrigated for pasture, hay, and grain. This soil is poorly suited to crops. The irrigated areas are best suited to permanent grass-legume pasture. Where water is scarce, crested wheatgrass could be grown. While a stand is being reestablished, a straw mulch helps prevent loss of soil through blowing and washing.

Deschutes sandy loam, shallow, 0 to 3 percent slopes (Dlc).—In many places this shallow soil lies between Deschutes sandy loam, 0 to 3 percent slopes, and Scabland. It is also associated with Deschutes sandy loam, stony, 0 to 3 percent slopes.

This soil is less than 16 inches deep over a layer of basalt, other lava bedrock, semiconsolidated sandy material, or other material that is impermeable to roots. The subsoil is thinner than that of Deschutes sandy loam, 0 to 3 percent slopes, and the surface soil is generally somewhat thinner. The water-holding capacity is low.

Fragments of basalt of various sizes are on the surface and in the surface soil, but they are not numerous enough to interfere materially with cultivation. In many places lime occurs in fissures in the substratum or as a thin coating over the substratum, but in a few places the lower part of the subsoil is not calcareous.

Use and management (subgroup 1C).—This soil generally appears to be better suited to irrigated grass-legume pasture than to crops. It is moderately well suited to potatoes, small grains, some of the clovers, and possibly vetch. It is poorly suited to alfalfa and other deep-rooted crops. Yields are much lower than on Deschutes sandy loam, 0 to 3 percent slopes.

This soil is used in much the same way as Deschutes sandy loam, 0 to 3 percent slopes, but a smaller part is used for alfalfa and a much larger part remains under natural cover and is used for range.

Where crops are to be harvested, a rotation consisting of a small grain, alsike clover, and potatoes is suggested. The alsike clover can be harvested for seed for a year or two and then used for pasture for a few years. This practice can also be followed, using Ladino clover, on newly cleared land or on other areas where weeds and volunteer white and alsike clovers are not bothersome. A 2-year rotation of small grain and vetch may be suitable on some farms. Pastures should include Ladino clover, alta fescue, orchardgrass, and perennial wheatgrass.

The fertilization suggested for Deschutes sandy loam, 0 to 3 percent slopes, should be suitable for this soil.

This soil needs frequent, light irrigations. Because the root zone is shallow, little leveling can be done. The strip-border method is used in some areas. Where the surface is very gently undulating or somewhat uneven, corrugations may be more suitable than strip borders.

Deschutes sandy loam, shallow, 3 to 7 percent slopes (Dle).—This gently sloping shallow soil is more likely to erode under irrigation than Deschutes sandy loam, shallow, 0 to 3 percent slopes. Like the more nearly level soil, this soil has a shallow root zone and limited water-holding capacity. The erosion hazard is moderate.

Use and management (subgroup 1F).—Nearly 50 percent of this soil is covered with juniper, sagebrush, and grass, and 40 percent is irrigated and used for crops and pasture. The use suitability and management needs of this soil are similar to those of Deschutes sandy loam, shallow, 0 to 3 percent slopes, but irrigation water must be distributed more carefully. Irrigations must be frequent and light. Many of the areas probably can be irrigated more effectively by the corrugation method or by flooding from contour laterals than by the strip-border method. In most places, it is probably best to use this soil for irrigated grass-legume pasture.

Deschutes sandy loam, shallow over cinders, 0 to 3 percent slopes (Dlo).—This inextensive shallow soil occurs west of Terrebonne. It is associated with Deschutes sandy loam, over cinders, 0 to 3 percent slopes. It is like the associated soil except that, in most places, it is about 16 inches or less in depth to the substratum of volcanic cinders or pumicy materials. It differs from Deschutes sandy loam, shallow, 0 to 3 percent slopes, in that its substratum is rapidly permeable.

Use and management (subgroup 1C).—Slightly more than one-half of this soil is covered with sagebrush and grass; about one-third is irrigated for crops and pasture, and the rest is mostly idle. This soil is similar in use suitability, yields, and management needs to Deschutes sandy loam, shallow, 0 to 3 percent slopes, but it requires more water and more frequent applications of water. This soil is fair to poor for crops.

Deschutes sandy loam, shallow over cinders, eroded, 3 to 7 percent slopes (Dls).—This inextensive soil occurs mainly west of Terrebonne, in association with Deschutes sandy loam, over cinders, 0 to 3 percent slopes, and other soils underlain by cinders. It is like the associated soil, except that it is about 16 inches or less in depth to the substratum of volcanic cinders or pumicy material, and it is moderately eroded in most areas. From 25 to 75 percent of the original topsoil has been lost, mostly as a result of irrigation.

Use and management (subgroup 1F).—About 60 percent of this soil is irrigated and used for crops and pasture, and 20 percent has a sagebrush cover. The rest is idle or in crested wheatgrass. In use suitability, yields, and management needs, this soil is similar to Deschutes sandy loam, shallow, 3 to 7 percent slopes, but apparently it requires more water and more frequent irrigations. This soil is best suited to irrigated grass-legume pasture.

Deschutes sandy loam, stony, 0 to 3 percent slopes (Dsa).—A considerable part of this soil lies in the nonirrigated region south and east of Redmond. Smaller areas are in irrigated districts. Except that it contains angular and subangular stones, this soil is similar to Deschutes sandy loam, 0 to 3 percent slopes. The stones range from less than 1 inch to 2 feet or more in diameter. Most of them are fragments of basalt; a few are fragments of rhyolite, andesite, or other kinds of rock. In most areas there are enough stones to interfere with tillage but not to prevent it.

Most areas of this soil could be cleared of stones and in the last few years some areas have been cleared. If the stones are removed from the surface soil, this soil is very similar to Deschutes sandy loam, 0 to 3 percent slopes, except that it has a stonier subsoil and, in many areas, is shallower to bedrock. In places lava bedrock crops out.

Deschutes sandy loam, stony, 0 to 3 percent slopes, is associated with Scabland, 0 to 3 percent slopes, and Scabland, 3 to 12 percent slopes. Included are some areas that have a surface soil of loamy sand or loamy coarse sand.

Use and management (subgroup 1A).—A considerable part of this soil is not irrigated and remains in its natural vegetation of juniper, sagebrush, rabbitbrush, grass, and herbs. Most of the irrigated areas are used for permanent grass-legume pasture, but a few of the less stony areas are used for various crops.

Most areas that have not been cleared of stones seem to be best suited to irrigated permanent grass-legume pasture. The nonirrigated areas seem best suited to grazing. If cleared of most of the stones, this soil is similar to Deschutes sandy loam, 0 to 3 percent slopes, in use suitability, management needs, and productivity.

Deschutes sandy loam, stony, 3 to 7 percent slopes (Dsb).—This soil is more difficult to irrigate and more likely to erode under irrigation than Deschutes sandy loam, stony, 0 to 3 percent slopes.

Use and management (subgroup 1D).—Most of this soil remains under the natural vegetation, but a small part is used for irrigated grass-legume pasture, and a few of the less stony areas are used for irrigated crops. Areas from which the stones are not removed seem best suited to grass-legume pasture if irrigated and to range if not irrigated. Most tracts can be cleared of stones. If the stones are removed, this soil is almost the same in use suitability, management needs, and productivity as Deschutes sandy loam, 3 to 7 percent slopes.

Deschutes sandy loam, stony, 7 to 12 percent slopes (Dsc).—This soil resembles Deschutes sandy loam, stony, 0 to 3 percent slopes, but because of the stronger slopes it is more difficult to irrigate and more likely to erode under irrigation. It is similar to the more nearly level soil in stoniness. A few acres have been moderately eroded. These areas are shown on the map by erosion symbols.

Use and management (subgroup 1G).—Most of this soil remains under the natural vegetation and is used for range; a few areas are used for irrigated grass-legume pasture. Because of the erosion hazard under irrigation, the feasibility of removing the stones and growing crops is doubtful. In most places irrigated grass-legume pasture seems the best use. If this soil is cleared of stones, it is similar in use suitability, management needs, and productivity to Deschutes sandy loam, 7 to 12 percent slopes.

Deschutes sandy loam, stony, over cinders, 3 to 7 percent slopes (Dsd).—This inextensive soil is underlain by the same kind of cindery or pumicy substratum as Deschutes sandy loam, over cinders, 0 to 3 percent slopes. It is similar to Deschutes sandy loam, stony, 3 to 7 percent slopes, in stoniness, present use, suitability for use, productivity, and management needs, but it requires more water and more frequent irrigations. In places wind erosion has removed considerable surface soil. This soil is in management subgroup 1D.

Deschutes sandy loam, stony, over semicemented sandy material, 0 to 3 percent slopes (Dse).—This soil occurs in the west-central part of the surveyed area of Deschutes County. It has a cemented layer in the lower subsoil or substratum at a depth of 2 or 3 feet. Apparently this cemented layer, or hardpan, is not a continuous impermeable layer, but contains fissures, weakly cemented places, or uncemented openings, through which water moves downward.

A considerable part of this soil has enough stones on the surface and in the surface soil to interfere with tillage. Most of the stones are subangular fragments of andesite and basalt. The degree of stoniness varies from place to place. If the stones are removed from the upper part, this soil is similar to Deschutes sandy loam, over semicemented sandy material, 0 to 3 percent slopes, except that its subsoil may be stonier.

Use and management (subgroup 1A).—All except a few small areas of this soil are covered with juniper, sagebrush, and grass. If the stones are removed, this soil is similar to Deschutes sandy loam, over semicemented sandy material, 0 to 3 percent slopes, in crop suitability and management needs. Areas that are not cleared of stones are best suited to grass-legume pasture if irrigated and to range if not irrigated.

Deschutes sandy loam, stony, over semicemented sandy material, 3 to 7 percent slopes (Dsl).—This soil is gently sloping or undulating and is more difficult to irrigate properly than Deschutes sandy loam, stony, over semicemented sandy material, 0 to 3 percent slopes.

Use and management (subgroup 1D).—Most of this soil is in its natural vegetation; only small areas are irrigated. If most of the stones are removed, this soil is similar in use suitability and management needs to Deschutes sandy loam, over semicemented sandy material, 3 to 7 percent slopes.

Deschutes sandy loam, stony, over semicemented sandy material, 7 to 12 percent slopes (Dso).—This inextensive soil occurs near Tumalo. It is of little agricultural importance. A small area that has slopes of 12 to 20 percent is included.

Use and management (subgroup 1G).—Practically all of this soil is in its natural vegetation. Because of the strong slopes, the difficulty of irrigating, and the high erosion hazard under irrigation, clearing stones from this soil probably is not practicable. Under irrigation, this soil is probably best suited to grass-legume pasture.

Era sandy loam

All of the Era sandy loam in the Area is in Jefferson County. Most of this extensive soil lies on the nearly level and undulating upland plains. Some of it occurs in more strongly sloping areas where the plains are more dissected, and some on the lower slopes of buttes. Much of this soil will be irrigated under the Deschutes Irrigation Project.

The normal annual precipitation is 8.5 to 10 inches. The natural vegetation consisted of big sagebrush, rabbitbrush, bunchgrasses, annual grasses, scattered junipers, and associated herbs.

The upper part of this soil has developed mostly from material weathered from partly consolidated sandstone, agglomerate, and other sedimentary strata of the Dalles formation. This material was mainly of volcanic origin chiefly andesite, basalt, and rhyolite. The parent material of the upper part of the soil probably contained some pumice particles, volcanic ash, and wind-borne silt.

The lower part of the profile was affected by materials weathered from basalt or other lava rock. Basalt bedrock commonly underlies this soil at a moderate depth.

This soil is associated with the Agency soils. It has developed from parent materials similar to those of Agency soils, in a similar climate, and under a similar kind of vegetation. The subsoil of Era sandy loam, however, is coarser textured than the Agency subsoil. Era sandy loam is somewhat similar to the Deschutes soils, but it contains less pumice and its subsoil is more friable.

The soil profile is weakly or very weakly developed. The subsoil is only slightly, if at all, finer in texture and more compact than the surface soil. Some lime has accumulated in the lower subsoil.

Typical profile:

0 to 9 inches, grayish-brown sandy loam grading to light brownish gray or brown; noncalcareous; slightly hard or soft; single-grain or weak very fine granular structure; when moist, very dark grayish brown and very friable.

9 to 25 inches, brown to grayish-brown sandy loam or light loam; noncalcareous; slightly hard; single grain or massive; when moist, dark brown to dark grayish brown; contains pebbles, more in lower part.

25 to 33 inches, brown gravelly sandy loam or loam, grading to grayish brown or pale brown; slightly calcareous; slightly hard; weak subangular blocky structure; commonly contains lime-coated angular rock fragments.

33 inches +, lime-coated basalt.

Partly because of the diversity of the stratified underlying material, this soil differs from place to place. The underlying material may be andesitic or rhyolitic lava, caliche, or more or less consolidated sandstone, agglomerate, or other sedimentary rock. The permeability of these layers differs. Normally this soil is 2 to 3 feet deep to a layer that is impermeable to roots, but it may be 5 or more feet deep. Included are some areas where the subsoil is finer in texture and less permeable than is typical.

In most places the upper layers contain a few red rhyolitic and gray or dark-gray andesitic and basaltic pebbles or subangular rock fragments. These pebbles or fragments are more numerous in the lower part of the profile. The upper part of the soil also contains a small quantity of pumice the size of fine and medium sand. This pumice sand was either deposited from the air following a volcanic eruption, or was part of the sedimentary parent material.

Era sandy loam apparently is low in organic matter and nitrogen, but not so low as the Deschutes soils. The surface soil commonly is about neutral in reaction, and the subsoil is normally mildly alkaline.

Drainage through the surface soil and subsoil is moderate to rapid. The underlying basalt is relatively impermeable except in places where fissures or cracks occur. This soil is normally well drained, but in some swales or level tracts excessive irrigation may cause a perched water table. In these places soluble salts may accumulate. Normally, however, this soil is not saline or alkaline.

To show variations in slopes and erosion, eight phases of this soil are mapped.

Era sandy loam, 0 to 3 percent slopes (Ea).—This is one of the better soils that will be irrigated under the Deschutes Irrigation Project. All of it lies north of the Crooked River, mainly in the nearly level upland plains. This soil is moderately deep and the water-holding capacity is moderate to high. Runoff is slow. The organic-matter content is low. The erosion hazard under irrigation will be slight, but in some areas wind erosion may be a hazard.

Use and management (subgroup 2A).—When this soil was mapped, 80 percent was used for dry-farmed crops, chiefly wheat alternating with summer fallow. Yields have been low. Nearly 10 percent was in sagebrush and grass. Most of the rest has been cultivated but is now in annual grasses or crested wheatgrass.

This soil is moderately to poorly suited to dry farming.

Except for a section not easily reached by canals, most of this soil will be irrigated. It will be easy to level and to irrigate. About the same kind of crops probably will be grown on this soil as are now grown on Deschutes sandy loam, 0 to 3 percent slopes. These crops include alfalfa, potatoes, oats, barley, wheat; Ladino, alsike, and red clovers for hay and seed; and perhaps peas for seed.

After a few years of cropping, yields on Era sandy loam, 0 to 3 percent slopes, are expected to increase slightly. This soil appears to be better suited to alfalfa and clover than Deschutes sandy loam, 0 to 3 percent slopes. It should be well suited to Ladino clover grown for seed, at least until the stand is invaded by weeds and other clovers.

Management needs under irrigation will be similar to those of Agency loam, 0 to 3 percent slopes, but irrigation runs should be shorter on this soil and applications of fertilizer somewhat heavier.

Era sandy loam, 3 to 7 percent slopes (Ec).—All of this gently sloping or undulating soil lies north of the Crooked River. It occurs near the edges of the nearly level upland plains and where the terrain is slightly more dissected. Many areas lie on the lower slopes of buttes. Runoff from rainfall is slow.

Use and management (subgroup 2B).—Most of this soil has been cropped. Only about 10 percent is in sagebrush and grass. Nearly half of the acreage that has been cropped, however, is now in grass, chiefly cheatgrass or other annuals and crested wheatgrass. Much of the soil that had been cropped was put in grass under a Federal land utilization project. The nonirrigated soil is similar in use suitability, yields, and management needs to Era sandy loam, 0 to 3 percent slopes.

A considerable part of this soil will be irrigated under the Deschutes Irrigation Project, but many tracts cannot easily be reached by canals. Under irrigation, this soil will be suited to about the same kind of crops as Era sandy loam, 0 to 3 percent slopes. It will be less well suited to potatoes and other row crops because, under irrigation, it will be erosive. It should remain in alfalfa, clover, or pasture as much as possible, perhaps two-thirds of the time. A grass should be planted with the alfalfa. Additions of organic matter are suggested.

It will be difficult to irrigate this soil without causing moderate erosion. Careful control of water will be necessary to prevent excessive runoff and washing. Corrugations may be better suited to this soil than strip borders, but runs should be rather short. Flooding from contour laterals may be satisfactory. Other management needs are rather similar to those of Agency loam, 0 to 3 percent slopes.

Era sandy loam, 7 to 12 percent slopes (Ee).—This sloping or rolling soil lies in the more dissected parts of the upland plains and along the lower slopes of buttes.

Use and management (subgroup 2C).—About one-third of this soil is in sagebrush and grass. One-fourth is used for dry-farmed grain, and most of the rest has been cropped but is now in annual grasses or crested wheatgrass. Yields of grain have been low. Some of the soil that had been cropped was put in grass under a Federal land utilization project.

Some of this soil will probably be irrigated under the Deschutes Irrigation Project, but much of it lies in positions that are difficult to supply with water. This soil is poorly suited to irrigation. It will be difficult to distribute water evenly without causing considerable erosion. If corrugations are used or if the soil is flooded from contour laterals, short runs are essential. Irrigated areas should be kept in alfalfa, clover, or grass-legume pasture most of the time, and a grain crop should be grown only as preparation for reseeding the pasture.

Era sandy loam, 12 to 20 percent slopes (Eg).—This soil occurs in scattered tracts in the more dissected parts of the upland plains and in the rougher sections in Jefferson County.

Use and management (subgroup 2D).—Half of this soil is in sagebrush and grass, and only about 6 percent is dry farmed. Most of the rest has been cropped but is now in annual grasses or crested wheatgrass. Some of this soil that had been cropped was put in grass under a Federal land utilization project.

Because irrigation would be likely to cause serious erosion, probably little or none of this soil will be irrigated. If any is irrigated it should be kept in grass-legume pasture.

Era sandy loam, eroded, 0 to 3 percent slopes (Eb).—This soil has been moderately eroded, chiefly by the wind. Much of the acreage has lost one-fourth or more of the original topsoil.

Use and management (subgroup 2A).—This soil should be managed in about the same way as Era sandy loam, 0 to 3 percent slopes, but its needs for additions of organic matter and for nitrogen-supplying crops are greater. Wind erosion of unirrigated areas can be controlled by planting grain in narrow strips alternating with strips of fallow soil.

Era sandy loam, eroded, 3 to 7 percent slopes (Ed).—This soil occurs mainly near Round, Haystack, and Juniper Buttes. A considerable part of it has lost 25 percent of the topsoil through erosion by water or wind, or both. In a few spots as much as 75 percent has been removed, and in other spots a few gullies have formed.

Use and management (subgroup 2B).—Much of this soil probably will be irrigated. It should be managed in about the same way as Era sandy loam, 3 to 7 percent slopes, but it will need more organic matter and nitrogen.

Era sandy loam, eroded, 7 to 12 percent slopes (Ef).—Many tracts of this soil are in the sloping or rolling uplands east of Culver. This soil has been moderately eroded by wind or water, or both. One-fourth or more of the original topsoil has been removed, and in spots a few gullies have formed.

This soil is in management subgroup 2C. It is managed in about the same way as Era sandy loam, 7 to 12 percent slopes, but yields are slightly lower.

Era sandy loam, eroded, 12 to 20 percent slopes (Eh).—This soil has been moderately eroded by water or wind, or both. Included are some areas on alluvial fans where the soil is deeper than normal and resembles Metolius sandy loam.

This soil is in management subgroup 2D. It needs about the same kind of management as Era sandy loam, 12 to 20 percent slopes.

Gem clay loam

Gem clay loam occurs in the southeastern part of the surveyed area of Jefferson County on the lower foot slopes of the nearby buttes. Except for the extreme southern and southwestern parts, this region receives more rainfall than the rest of the Area. The normal annual precipitation is probably about 11 or 12 inches. The natural vegetation consists mainly of big sagebrush and bunchgrasses, but it includes some junipers, bitterbrush, rabbitbrush, and associated herbs. Cheatgrass is common.

This soil was formed mainly from material weathered from basalt. Most of it is underlain by basalt bedrock. In some areas the parent material was probably old alluvial or colluvial material that collected on alluvial fans on the foot slopes of the nearby buttes. Andesite, rhyolite, and other material are mixed with the basalt. This soil contains little or no pumice.

This soil is darker colored than the Lamonta soils. The profile is moderately to strongly developed but less strongly developed than the profile of the Lamonta soils.

Typical profile:

0 to 8 inches, grayish-brown to dark grayish-brown or dark-gray noncalcareous hard clay loam; fine granular structure; when moist, very dark gray or very dark grayish brown and firm; when wet, plastic.

8 to 20 inches, noncalcareous clay or heavy clay loam, slightly lighter colored than layer above; very weak prismatic structure that breaks into very hard, dense, subangular blocky aggregates about ½ inch in diameter; shiny colloidal coating on the aggregates is darker colored than the soil material; when moist, dark grayish brown or dark brown and very firm or firm.

20 to 28 inches, similar to layer above but brown, slightly less hard, and not prismatic; contains many large white lime splotches.

28 to 38 inches, rather similar to layer above, but light yellowish brown or pale brown; slightly coarser texture and less distinct structure; contains many rock fragments.

38 inches +, lime-coated fragments of basalt over basalt bedrock.

In many places the upper few inches of this soil is platy. A few angular or subangular rock fragments occur in the surface soil; they are more numerous with increasing depth. These fragments are dark colored; in places some are red rhyolitic rocks.

The upper layer of this soil contains moderate amounts of organic matter and nitrogen and is about neutral in reaction. Drainage is moderate to slow through the surface soil, slow through the subsoil, and very slow through the substratum.

Because of the combination of more precipitation and a finer texture, Gem clay loam supports a denser stand of grasses and associated herbs than other soils in the Area. Consequently it is the darkest colored soil in the Area; it is also the most fertile and has the best supply of organic matter and nitrogen.

To show variations in slope, erosion, and depth to bedrock, four phases of this soil are mapped.

Gem clay loam, eroded, 3 to 12 percent slopes (Ga).—This soil occurs southeast of Haystack Butte, on upland plains or the foot slopes of buttes. It is gently sloping to moderately sloping, or undulating to rolling. This soil occurs in a region where rainfall is higher than it is in most of the Area. A considerable part of this soil has been moderately eroded by water or wind, or both. Runoff ranges from slow to moderate. When wet, this soil is sticky and difficult to till. Workability is only fair. This soil has better water-holding capacity than most of the soils in the Area, and also contains more organic matter and nitrogen.

Use and management (group 3).—Almost 40 percent of this soil is used for dry-farmed grain and left fallow every other summer. The rest has been cropped but is now in grasses, chiefly crested wheatgrass, and is used for grazing. Much of this area was put in grass under the Federal land utilization project.

This is one of the better soils for dry-farmed grain. It seems better suited to winter wheat than to spring wheat. Yields are normally 15 to 17 bushels an acre, but they range from 5 to 25 bushels, depending on the amount of rainfall.

This soil would be only fair for irrigated crops. Because of its location, probably none of it will be irrigated.

Gem clay loam, eroded, 12 to 20 percent slopes (Gb).—This soil occurs in a few tracts southeast of Haystack Butte. It is strongly sloping or rolling to hilly. Most of it has been moderately eroded, chiefly by water. In areas not protected by vegetation, runoff is moderate. Included are some areas in which the surface soil is loam instead of clay loam. These areas are more easily tilled than the typical soil.

Use and management (group 3).—About 40 percent of this soil is used for dry-farmed grain, 15 percent is under sagebrush and grass, and the rest is in grass and is used for grazing.

Because of strong slopes and erodibility, this soil is not well suited to dry-farmed grain. Farm machinery is difficult to use on the strong slopes. Yields are lower on this soil than on Gem clay loam, eroded, 3 to 12 percent slopes.

Probably none of this soil will be irrigated under the Deschutes Irrigation Project. It is poorly suited to irrigated crops, but it could be used for irrigated pasture.

Gem clay loam, shallow, 7 to 12 percent slopes (Gc).—This soil occurs east and northeast of Haystack Butte. It differs from Gem clay loam, 7 to 12 percent, in that (1) it is generally less than 16 inches deep over bedrock; (2) its surface soil and subsoil are coarser textured; (3) its surface soil is lighter colored; (4) it contains more pebbles and rock fragments; and (5) its subsoil contains less lime.

Use and management (subgroup 2I).—Little of this soil has been cleared of its native sagebrush and grass. Because it is shallow and low in water-holding capacity, it is poorly suited to dry-farmed grain. If it is not irrigated, it should be used for range. Probably none of this soil will be irrigated. If any is irrigated, it should be used for permanent pasture.

Gem clay loam, shallow, eroded, 7 to 12 percent slopes (Gd).—This shallow or rolling soil occurs southeast of Haystack Butte. It has been moderately eroded. About 20 acres of a similar soil having 12 to 20 percent slopes and only slight erosion are included.

Use and management (subgroup 2I).—Nearly all of this soil is in sagebrush and grass. Because the soil is shallow and low in water-holding capacity, it is poorly suited to dry farming. Probably none will be irrigated. If it is irrigated, it would be suited to permanent pasture.

Gem loam

Except that it is coarser in texture, Gem loam is similar to Gem clay loam. In most places the surface soil is loam, silt loam, or heavy loam, and the subsoil is heavy clay loam. Drainage is moderate through the surface soil and slow through the subsoil.

To show variations in slope and erosion, three phases of this soil are mapped.

Gem loam, 3 to 7 percent slopes (Ge).—This soil occurs southeast and west of Haystack Butte, in spots where rainfall is greater than in most of the Area. This soil absorbs and holds water better than most soils of the Area, and also contains more organic matter and nitrogen. Runoff is rather low, and tilth is fairly good. Included are 18 acres where the slopes range from 0 to 3 percent, and a few acres where about one-fourth or more of the original surface soil has been removed by water or wind, or both.

Use and management (group 3).—About 75 percent of this soil is used for dry-farmed grain; the grain is alternated with summer fallow. About 6 percent is in sagebrush and grass. The rest of the soil has been cropped but is now chiefly in crested wheatgrass.

This is the best soil in the Area for dry-farmed grain. Dry-farming practices are similar to those on Gem clay loam, eroded, 3 to 12 percent slopes, but workability is better on this soil. Yields are about the same or slightly higher. Because of its location, probably none of this soil will be irrigated.

Gem loam, 7 to 12 percent slopes (Go).—This soil occurs in one tract northeast of Haystack Butte. Runoff is slow to moderate, but some erosion may occur during heavy rains or when snow melts. Workability is good.

Use and management (group 3).—This soil is slightly less well suited to dry-farmed grain than Gem loam, 3 to 7 percent slopes, but yields should be almost as high. Although this soil was formerly cultivated, all of it is now in grass, chiefly crested wheatgrass. The area is included in the Federal land utilization project. This soil is not likely to be irrigated soon. Under irrigation it would be only fair for crops, but it could be used for permanent pasture and hay.

Gem loam, eroded, 7 to 12 percent slopes (Gs).—This soil occurs east, northeast, and southeast of Haystack Butte. It has been moderately eroded. About one-fourth or more of the original surface soil has been removed by water or wind. A few shallow gullies have formed in places.

Use and management (group 3).—This soil was included in the Federal land utilization project. At present, 85 percent of it is in grass, chiefly crested wheatgrass. About 10 percent is in sagebrush and grass, and 5 percent is in dry-farmed grains. Because it is more strongly sloping and has more rapid runoff, this soil is less well suited to dry-farmed wheat than Gem loam, 3 to 7 percent slopes. Yields probably would be lower. This soil is not likely to be irrigated soon.

Laidlaw sandy loam

Laidlaw sandy loam occurs in rather small tracts in the undulating to rolling uplands of the southwestern parts of the Area, particularly southwest of Laidlaw Butte. The normal annual precipitation is about 11 to 13 inches. The frost-free season is usually short. Near Laidlaw Butte the native vegetation consists of big sagebrush, an open stand of juniper, and some rabbitbrush and bunchgrasses. Areas of this soil west of Bend support, in addition, some ponderosa pine and bitterbrush.

This soil developed in a 2- to 3-foot layer of pumice sand. Mixed with the pumice sand were small crystals of plagioclase, hypersthene, augite, and hornblende, and also some dark-gray or gray sand, coarse sand, or angular fragments of basalt or andesite, an inch or less in diameter. This material was carried by the wind from places south and southwest of the Area where volcanic eruptions had occurred. It was deposited over pumice that apparently erupted from Laidlaw Butte, and was subsequently somewhat reworked by wind and water.

The parent material is somewhat weathered. The subsoil is somewhat compacted, and weak structural aggregates have formed. In most places a hard cemented layer occurs at a depth of 2½ or 3 feet. The cementation may occur in the top part of the pumice flow material.

This soil differs from the typical Deschutes sandy loam in being entirely noncalcareous, probably because it receives more rainfall.

Typical profile:

0 to 7 inches, grayish-brown soft light sandy loam grading to brown or light brownish gray; single grain; contains much light yellowish-brown, pale-brown, or very pale brown pumice sand; some pumice particles are as large as ⅛ inch; when moist, very dark grayish brown and very friable.

7 to 17 inches, similar to layer above but slightly browner and lighter colored.

17 to 23 inches, pale-brown light sandy loam; breaks into weak, slightly hard or hard, rounded or subangular blocky aggregates ½ to ¾ inch in diameter; contains much pumice similar to that in surface layer; when moist, dark grayish brown and firm to friable.

23 to 30 inches, soft or slightly hard gravelly loamy sand that is similar to layer above in color; contains many rounded or subangular pumice pebbles as large as 1½ inches in diameter.

30 inches +, light gray splotched with yellowish brown, weakly to strongly cemented pumice flow material; material consists of fine sandy material among rounded to angular pumice pebbles and lumps as large as 10 inches in diameter; pebbles and lumps are light in weight and vesicular or spongelike; when wet, lumps are mainly yellowish brown on the inside; in most places layer is capped by an indurated film about 1/20 inch thick that is apparently cemented by siliceous material and can be broken only by a pick or heavy bar.

In places scattered basalt stones as large as 1 foot in diameter occur on or in this soil. The surface soil contains a little organic matter. This soil is about neutral; in places it grades from slightly acid in the surface soil to mildly alkaline in the subsoil. Drainage through the surface soil and subsoil is rapid, but drainage appears to be very slow or slow through the underlying layer.

To show variations in slope and erosion, five phases of this soil are mapped.

Laidlaw sandy loam, 0 to 3 percent slopes (La).—This nearly level soil occurs southwest of Laidlaw Butte and west of Bend. In this region the frost-free season is normally about 96 days, but it ranges from 47 to 143 days.

Use and management (subgroup 1A).—About 57 percent of this soil is in its natural vegetation, 26 percent is irrigated for crops and pasture, and the rest is used for farmsteads, range, or other purposes.

In use and management this soil is somewhat similar to Deschutes sandy loam, 0 to 3 percent slopes, and Deschutes loamy sand, 0 to 3 percent slopes. The frost-free season may be too short for potatoes and for alfalfa. Under irrigation this soil is best suited to small grains, vetch for seed, alsike clover for seed and hay, and red clover. Possibly strawberries can be grown.

A few acres of this soil are sometimes used to grow dry-farmed rye for hay or grain, but yields are low.

Laidlaw sandy loam, 3 to 7 percent slopes (Lb).—This soil is gently sloping or undulating and therefore is more likely to erode under irrigation than Laidlaw sandy loam, 0 to 3 percent slopes. Runoff from rainfall is rather low.

Use and management (subgroup 1D).—About 82 percent of this soil is in natural vegetation, and only about 11 percent is used for crops and pasture. Most of the acreage used for crops and pasture is irrigated, but a little is used to grow dry-farmed rye for hay or grain.

In use and management this soil is similar to Laidlaw sandy loam, 0 to 3 percent slopes. It is suited to irrigated pasture. Irrigation runs should be short to prevent erosion.

Laidlaw sandy loam, 7 to 12 percent slopes (Lc).—This soil is sloping or rolling and consequently is difficult to irrigate effectively. The erosion hazard under irrigation is high.

Use and management (subgroup 1G).—About 82 percent of this soil is in its natural vegetation; most of the rest is irrigated for crops and pasture. A few acres may be used to grow dry-farmed rye for hay or grain.

This soil is poor for irrigated or dry-farmed crops. It is better suited to pasture.

Laidlaw sandy loam, eroded, 7 to 12 percent slopes (Ld).—This soil occurs southwest of Laidlaw Butte. It has been moderately eroded, chiefly by water.

Use and management (subgroup 1G).—About 65 percent of this soil is used for irrigated crops and pasture, and 20 percent is in its natural vegetation. A few acres is in dry-farmed rye or other small grain for hay or grain.

This soil is poorly suited to irrigated or dry-farmed crops. The irrigated areas can be used for permanent pasture. The nonirrigated areas can be seeded to crested wheatgrass.

Laidlaw sandy loam, eroded, 12 to 20 percent slopes (Le).—This inextensive soil is strongly sloping or hilly. The runoff from rainfall is not rapid, but the erosion hazard under irrigation is very high. Effective distribution of water is difficult.

Use and management (subgroup 1I).—About two-thirds of this soil is used for crops and grass pasture. Some of the pasture is irrigated. About one-third remains in its natural vegetation. On a few acres dry-farmed rye is grown for hay or grain. The irrigated areas can be used for grass-legume pasture. The nonirrigated soil can be seeded to crested wheatgrass.

Lamonta loam

Lamonta loam occurs extensively in Jefferson County, on nearly level or dissected upland plains and along the adjoining lower slopes of buttes. The annual precipitation ranges from about 8.5 to 11 inches. The natural vegetation consists of big sagebrush, bunchgrasses, annual grasses, rabbitbrush, scattered junipers, and associated herbs.

This soil was derived from mixed weathered materials that contained much rhyolitic and apparently some andesitic and basaltic materials. A considerable part of the soil material apparently was derived from the partly consolidated sandstone and agglomerate of the Dalles formation. In many places, however, the parent material may be old water-spread or colluvial materials that came from nearby buttes. The upper part of the soil may contain some wind-blown fine pumice and possibly some volcanic ash and windblown silt.

Lamonta loam is associated with Agency and Madras soils. Unlike these soils, it typically has a compact clay subsoil that is finer textured than the surface soil. The subsoil of the Agency and Madras soils is no finer in texture than clay loam.

Representative profile:

0 to 10 inches, grayish-brown, noncalcareous, slightly hard loam; fine granular structure; neutral reaction; when moist, very dark brown or very dark grayish brown and friable; in most places, layer grades into the layer below.

10 to 19 inches, dark-brown clay grading toward brown or dark grayish brown; noncalcareous; weak prismatic structure that breaks into very hard, dense, fine and medium-sized angular blocky aggregates; aggregates have glossy colloidal coating; neutral or mildly alkaline; sticky and plastic when wet.

19 to 26 inches, similar to layer above but lighter in color and moderately alkaline.

26 to 33 inches, very pale brown, pink, or light yellowish-brown very hard clay or clay loam; contains pebbles and small subangular rock fragments; fine angular blocky structure; very highly calcareous; veins and splotches of white lime; in places, soft caliche.

33 inches +, weathered, partly consolidated sandstone, agglomerate, or cobbly and stony fluvial deposits; generally calcareous in the upper part; in places, rhyolite, basalt, or other lava.

In many places a layer of hard subangular blocky clay loam, 2 to 8 inches thick, occurs in the upper subsoil between the surface soil and the dense clay layer. Included are areas where the subsoil is coarser and more permeable than typical.

Lamonta loam generally contains a small to moderate number of pebbles or subangular fragments of red rhyolite, some pebbles or fragments of gray or dark-gray andesite or basalt, and a few pebbles of quartz. Most of these pebbles and fragments are less than 1 inch in diameter, but a few are as large as 3 or 4 inches. They are generally more numerous in the lower subsoil.

Drainage is moderate through the surface soil, very slow or slow through the subsoil, and slow in most places through the underlying material. This soil is naturally nonsaline and nonalkaline. The organic-matter content is low to moderate.

To show variations in slope, depth, stoniness, and erosion, 15 phases of this soil are mapped.

Lamonta loam, 0 to 3 percent slopes (Lf).—This nearly level soil occurs in Jefferson County, near the outer edges of the Agency Plains and the plains south of Culver and near Opal City. It occurs elsewhere in Jefferson County in nearly level tracts on the more dissected upland.

Runoff is slow, but the soil may be damaged by wind erosion when it is not protected. The water-holding capacity is moderate to somewhat high. The erosion hazard under irrigation is slight.

Use and management (subgroup 2E).—Between two-thirds and three-fourths of this soil is used for dry-farmed small grains, chiefly winter wheat. Perhaps one-half of the rest of the soil is in sagebrush and grass. Some areas that have been cropped are in crested wheatgrass or other grasses and are grazed.

Yields of winter wheat are about 11 bushels an acre, but vary from year to year depending on rainfall. In the vicinity of Haystack Butte, precipitation is higher than in most of the Area; consequently, yields are slightly better.

Much of this soil will be irrigated under the Deschutes Irrigation Project. Some tracts, however, are located above the canal or in other locations that are difficult to supply with water. This soil should be fairly well suited to irrigated pasture and to several irrigated crops—oats, barley, wheat; and Ladino clover, peas, and vetch grown for seed. It is less well suited to alfalfa, red clover, alsike clover, and other deep-rooted crops. Because of the clay subsoil, it is not well suited to potatoes.

This soil should be easy to prepare for irrigation. Deep grading should be avoided, because it will expose the clayey subsoil, which takes water slowly and is difficult to work. On areas that are nearly level, irrigation runs can be longer than on most of the soil. This soil needs about the same fertilization as Agency loam, 0 to 3 percent slopes.

Lamonta loam, 3 to 7 percent slopes (Lh).—This soil occurs in Jefferson County in the somewhat dissected upland plains and along the lower foot slopes of Haystack, Juniper, and Round Buttes. It is gently sloping or undulating and therefore more likely to erode under irrigation than Lamonta loam, 0 to 3 percent slopes.

Use and management (subgroup 2F).—Nearly half of this soil is used for dry-farmed grain under management similar to that used on Lamonta loam, 0 to 3 percent slopes. Yields are slightly less. About one-fourth is in sagebrush and grass. Most of the rest has been cropped, but is now in crested wheatgrass or cheatgrass. Much of this acreage was seeded to grass under a Federal land utilization project.

Half or more of this soil probably will be irrigated under the Deschutes Irrigation Project. It should be managed in about the same way as Lamonta loam, 0 to 3 percent slopes, but it is not so well suited to irrigation. Sod or close-growing crops will help to control erosion. The corrugation method of irrigation is probably more suitable for this soil than the strip-border method.

Lamonta loam, 7 to 12 percent slopes (Lm).—This sloping or rolling soil occurs in Jefferson County on the dissected upland plains and along the lower slopes of buttes.

Use and management (subgroup 2G).—About 55 percent of this soil is in sagebrush and grass, and 20 percent is in dry-farmed crops. The rest has been cropped but is now in crested wheatgrass or cheatgrass. Some was seeded to grass under a Federal land utilization project. Yields of grain are a little lower on this soil than on the less strongly sloping Lamonta loams.

Under dry farming, runoff is rather slow, but this soil is somewhat erodible. Stubble should be left on the surface to protect the soil against erosion. Contour tillage will also retard erosion.

Some of this soil probably will be irrigated. It is rather poorly suited to irrigation. If water is not efficiently controlled, it may cause considerable erosion. Severe erosion is more damaging to this soil than to soils that have more permeable subsoils. Under irrigation this soil is better suited to permanent grass-legume pasture, oats, barley, and wheat than to most other crops.

Lamonta loam, 12 to 20 percent slopes (Lo).—This moderately steep or hilly soil occurs inextensively in Jefferson County in several widely scattered tracts. Some of this soil has a subsoil that is shallower, coarser textured, and less dense than the subsoil of Lamonta loam, 0 to 3 percent slopes.

Use and management (subgroup 2H).—Slightly more than half of this soil is in native vegetation. The rest has been cultivated but is now in annual grasses or crested wheatgrass and is used for range. Yields of dry-farmed crops were rather low. Because of the strong slopes, it is difficult to use large farming implements efficiently.

This soil would be poor for irrigated crops and should be kept in permanent grass-legume pasture.

Lamonta loam, eroded, 0 to 3 percent slopes (Lg).—This soil has been moderately eroded by water or wind, or both; about one-fourth or more of the original surface soil has been removed. In many places, deep plowing turns up some of the clay subsoil. This results in a more clayey surface soil, which impedes the infiltration of water. Consequently the suitability of this soil for crops, especially irrigated crops, is reduced.

Use and management (subgroup 2E).—This soil is in the same management subgroup as Lamonta loam, 0 to 3 percent slopes, but it is less well suited to agriculture and it needs more organic matter, nitrogen, and other fertilizer.

Lamonta loam, eroded, 3 to 7 percent slopes (Lk).—This soil has been moderately eroded; a large part of it has lost 25 percent or more of the original surface soil. Shallow gullies have formed in a few places. In many places, deep plowing will bring up some of the clay subsoil. The clay causes poorer tilth and makes the surface soil hard when dry and sticky and plastic when wet. Consequently the soil will be more difficult to work, and runoff probably will be increased. Thus the soil will be less suitable for crops, particularly irrigated crops.

Use and management (subgroup 2F).—This soil is in the same management subgroup as Lamonta loam, 3 to 7 percent slopes, but it needs more organic matter and nitrogen. Yields are lower on this soil.

Lamonta loam, eroded, 7 to 12 percent slopes (Ln).—This soil has been moderately eroded; much of it has lost from 25 to 75 percent of the original surface soil. Shallow gullies have formed in a few places. In many places, deep plowing turns up some of the clay subsoil and causes the plow layer to be harder when dry and more sticky and plastic when wet.

Use and management (subgroup 2G).—About 22 percent of this soil is in sagebrush and grass, and 34 percent is in dry-farmed small grains. Most of the rest has been cultivated but is now in crested wheatgrass or cheatgrass and is used for range. This soil is less suitable for crops than Lamonta loam, 7 to 12 percent slopes, and produces lower yields. If irrigated, it is suited to grass-legume pasture.

Lamonta loam, eroded, 12 to 20 percent slopes (Lp).—This soil has lost from 25 to 75 percent of its original surface soil through erosion. Shallow gullies have formed in a few places. Deep plowing mixes some of the clay subsoil with the surface soil and causes the surface soil to become harder when dry and more sticky when wet. This soil is somewhat shallower than the more nearly level Lamonta loams and has a coarser, more permeable subsoil.

Use and management (subgroup 2H).—About 35 percent of this soil is in sagebrush and grass, and 7 percent is used for dry-farmed grains. Much of the rest has been cropped but is now in crested wheatgrass or cheatgrass and is grazed. Yields are low. This soil is poorly suited to irrigated crops. If irrigated, it should be kept in permanent grass-legume pasture.

Lamonta loam, shallow, 0 to 3 percent slopes (Lr).—This soil occurs north of Gateway and south of Juniper Butte. It is only about 16 inches or less in depth to the underlying sandstone, rhyolite, or basalt. The lower part of the subsoil may be noncalcareous or only slightly calcareous, but some lime commonly occurs in fissures in the underlying rock. Because this soil is shallow, its water-holding capacity is low. Included in the mapping unit is a small acreage that is moderately eroded.

Use and management (subgroup 2I).—About two-thirds of this soil is in sagebrush and grass. The rest has been cropped but is now in cheatgrass or crested wheatgrass and is used for grazing.

This soil is poorly suited to dry-farmed grains. It is better suited to crested wheatgrass that is grown for grazing. This soil is less well suited to irrigated crops than the deeper Lamonta loams, but oats, barley, wheat, peas, and vetch should do fairly well if water is applied when needed.

Lamonta loam, shallow, 3 to 7 percent slopes (Ls).—This soil is 16 inches or less in depth to the underlying sandstone, rhyolite, or basalt. Its water-holding capacity is low. It is difficult to irrigate this soil effectively without causing erosion.

Use and management (subgroup 2I).—About two-thirds of this soil is in natural vegetation. A few acres are used for dry-farmed grain, and a few acres are in cheatgrass or crested wheatgrass. This soil is poorly suited to dry-farmed grain. Irrigated oats, barley, wheat, and vetch should do fairly well if water is applied when needed.

Lamonta loam, shallow, eroded, 3 to 7 percent slopes (Lt).—This soil is moderately eroded. Clay in the subsoil has been exposed and tilth impaired.

Use and management (subgroup 2I).—Nearly half of this soil is in sagebrush and grasses. About 15 percent is used for dry-farmed crops. The rest has been planted to crested wheatgrass or is in cheatgrass. This soil is suitable for about the same uses as Lamonta loam, shallow, 3 to 7 percent slopes.

Lamonta loam, shallow, eroded, 7 to 12 percent slopes (Lu).—This soil is about 16 inches or less in depth to the underlying rock. Its water-holding capacity is low.

Use and management (subgroup 2I).—About 80 percent of this soil is under its natural vegetation; 10 percent is used for dry-farmed crops.

This soil is poorly suited to dry-farmed grain. Because it is difficult to distribute water evenly, this soil is also poorly suited to irrigated crops. If it is irrigated, it should be used for permanent grass-legume pasture.

Lamonta loam, stony, 0 to 3 percent slopes (Lv).—This soil occurs in Jefferson County, much of it around the edges of the nearly level Agency Plains. It contains many tones. Much of it is somewhat shallower than Lamonta loam, 0 to 3 percent slopes, and a considerable part apparently is underlain by basalt, rhyolite, or other lava rock instead of sandstone and agglomerate. Included are several eroded areas from which one-fourth or more of the original surface soil has been removed. These areas are shown on the soil map by erosion symbols.

Except in a few places, this soil is too stony to be tilled. Most of the stones are angular fragments of basalt, but in places red rhyolite or other kinds of stone predominate. The stones range from a few inches to 20 inches or more in diameter. In places, the bedrock outcrops at the surface.

Use and management (group 6).—About 90 percent of this soil is in sagebrush and grass and is used for grazing.

The stones make it difficult to prepare this soil for seeding grass. If the stones were removed, areas that could conveniently be irrigated would be suitable for permanent grass-legume pasture.

About 5 percent of this soil is used for dry-farmed grain. Only areas from which some of the stones have been removed are suitable for crops.

Lamonta loam, stony, 3 to 7 percent slopes (Lw).—This gently sloping or undulating soil is more difficult to irrigate evenly than Lamonta loam, stony, 0 to 3 percent slopes. The mapping unit includes several areas from which one-fourth or more of the original surface soil has been removed by erosion.

Use and management (group 6).—Almost all of this soil is under natural vegetation. In use and management this soil is similar to Lamonta loam, stony, 0 to 3 percent slopes, but it is less well suited to permanent irrigated grass-legume pasture.

Lamonta loam, stony, 7 to 12 percent slopes (Lx).—This soil occurs in large tracts near Round Butte. It is sloping or rolling and has more rapid runoff than Lamonta loam, stony, 0 to 3 percent slopes. Included are areas that are moderately eroded.

Use and management (group 6).—Nearly all of this soil is under natural vegetation. In use and management it is similar to Lamonta loam, stony, 0 to 3 percent slopes, but it is less well suited to permanent irrigated pasture.

Lamonta sandy clay loam

Lamonta sandy clay loam is similar to Lamonta loam except for its surface soil, which is somewhat harder when dry, more sticky and plastic when wet, more difficult to work, and slightly less permeable to water. Furthermore, it may hold more water than the surface soil of Lamonta loam and may contain slightly less organic matter and nitrogen. In places, the surface soil of Lamonta sandy clay loam is slightly darker colored than is typical. Included are some areas of clay loam and gritty loam.

To show variations in slope, erosion, depth, and stoniness, 15 phases of this soil are mapped.

Lamonta sandy clay loam, 0 to 3 percent slopes (Ly).—This soil occurs in Jefferson County in several widely scattered areas. Runoff is rather slow, but unprotected areas may be damaged by wind erosion.

Use and management (subgroup 2E).—About 40 percent of this soil is in sagebrush and grass, and 35 percent is in dry-farmed grain. Much of the rest has been cultivated but is now in crested wheatgrass or cheatgrass and used for grazing. Yields of grain are low.

In use suitability and management this soil is similar to Lamonta loam, 0 to 3 percent slopes, but because it tends to be hard when dry and sticky when wet, it is less easily worked. It is too fine textured to be suitable for potatoes. It needs an increase of organic matter.

Much of this soil probably will be irrigated. Either the strip-border or the corrugation method of irrigation can be used. This soil should be leveled carefully so that the fine-textured subsoil will not be exposed.

Lamonta sandy clay loam, 3 to 7 percent slopes (Lea).—This gently sloping or undulating soil occurs in Jefferson County in several scattered areas. It occupies moderately dissected upland plains and the foot slopes of buttes. Runoff from rainfall is somewhat slow to moderate.

Use and management (subgroup 2F).—About 20 percent of this soil is in sagebrush and grass, and 10 percent is used for dry-farmed crops. Most of the rest has been cultivated but is now in crested wheatgrass or annual grasses. Yields of grain are rather low; near Haystack Butte they are slightly higher than in other areas.

A considerable part of this soil may be irrigated. Irrigation would be easy, and the erosion hazard under irrigation would be slight or moderate. This soil can be irrigated by the corrugation method or by flooding from contour laterals. Most of the time a sod or close-growing crop should be grown. Permanent grass-legume pasture should do well. This soil is not suited to potatoes.

Lamonta sandy clay loam, 7 to 12 percent slopes (Led).—This sloping or rolling soil occurs in the dissected parts of the uplands and along the lower slopes of buttes. Runoff from rainfall is moderate to slow. Under irrigation the erosion hazard is high to moderate.

Use and management (subgroup 2G).—About 10 percent of this soil is in sagebrush and grass, and about 25 percent is used for dry-farmed grain. Much of the rest has been cropped but has now been sown to crested wheatgrass under a Federal land utilization project.

In use and management this soil is similar to Lamonta loam, 7 to 12 percent slopes, but it is somewhat more difficult to work and is even more poorly suited to potatoes.

Lamonta sandy clay loam, eroded, 0 to 3 percent slopes (Lz).—This soil has been moderately eroded, chiefly by wind; much of the acreage has lost one-fourth or more of the original surface soil.

Use and management (subgroup 2E).—About 50 percent of this soil is used for dry-farmed grain, and 10 percent is in natural vegetation. Most of the rest has been cultivated but is now in crested wheatgrass or annual grasses and is used for grazing. Yields are rather low; they are somewhat higher in the areas near Haystack Butte than in other areas of this soil. In use and management this soil is similar to Lamonta sandy clay loam, 0 to 3 percent slopes.

Lamonta sandy clay loam, eroded, 3 to 7 percent slopes (Lec).—This soil has been moderately eroded by water or wind; about one-fourth or more of the surface soil has been lost. Deep plowing may turn up some of the clay subsoil and thus impair tilth.

Use and management (subgroup 2F).—About 20 percent of this soil is in sagebrush and grass, and about 25 percent is used for grazing. Much of the rest has been cultivated but is now in crested wheatgrass and is used for grazing. In use and management this soil is similar to Lamonta sandy clay loam, 3 to 7 percent slopes.

Lamonta sandy clay loam, eroded, 7 to 12 percent slopes (Leh).—This soil has been moderately eroded; from much of it, one-fourth to three-fourths of the original surface soil has been removed by wind or water, or both. In many places deep plowing turns up some of the finer textured subsoil. As a result, workability is impaired and infiltration of water is impeded. Runoff from rainfall is moderate, and the erosion hazard under irrigation is high to moderate. Because the topsoil is hard when dry and sticky when wet, workability of this soil is only fair.

Use and management (subgroup 2G).—About 10 percent of this soil is in sagebrush and grass. An equal acreage is used for dry-farmed grain. Much of the rest has been cropped but is now in crested wheatgrass or annual grasses and is used for grazing. Controlled grazing of crested wheatgrass is a suitable use for unirrigated areas of this soil. Stubble mulching helps to prevent erosion in cropped areas.

This soil is difficult to irrigate, but some of it probably will be irrigated. If irrigated, it will be better suited to permanent pasture than to crops.

Lamonta sandy clay loam, eroded, 12 to 20 percent slopes (Ler).—This strongly sloping or hilly soil has been moderately eroded; from much of it, one-fourth to three-fourths of the original surface soil has been removed by water or wind. Deep plowing will bring up some of the finer textured subsoil. Runoff is moderate. Workability is fair to poor. This soil is shallower than the typical Lamonta sandy clay loam and has a somewhat coarser and less dense subsoil.

Included are a few acres that are only slightly eroded and about 25 acres of soil that is only 16 inches deep or less.

Use and management (subgroup 2H).—Some of this soil is in sagebrush and grass, some is in crested wheatgrass, and some is used for dry-farmed grain. Yields are low. One of the best crops for this soil is crested wheatgrass. If this soil is cultivated, stubble mulching and contour tilling are needed to prevent erosion.

This soil is poorly suited to irrigation. If it is irrigated, it should be used for permanent grass-legume pasture.

Lamonta sandy clay loam, shallow, 0 to 3 percent slopes (Lev).—This soil occurs in two areas north of Juniper Butte. Unlike the typical Lamonta sandy clay loam, this soil is only about 16 inches or a little less in depth to partly consolidated sandstone, agglomerate, rhyolite, basalt, or other rock. In places the lower part of the subsoil is only slightly calcareous, but lime commonly occurs in fissures in the underlying rock. Nearly half of this soil has lost one-fourth of the original surface soil through wind or water erosion. Such areas are shown on the soil map by erosion symbols.

Use and management (subgroup 2I).—Nearly all of this soil is in sagebrush and grass. A little of it was once cropped. Because this soil is shallow and somewhat low in water-holding capacity, it is poorly suited to dry-farmed grain. It is better suited to crested wheatgrass grown for grazing. Under irrigation, this soil is less well suited to crops than the deeper soils, but oats, barley, wheat, peas, and vetch should do fairly well.

Lamonta sandy clay loam, shallow, 3 to 7 percent slopes (Lsa).—This soil occurs in two areas east of Culver. Unlike the typical Lamonta sandy clay loam, this soil is only about 16 inches or a little less in depth to the underlying rock, and in places it is noncalcareous or only slightly calcareous. The water-holding capacity is somewhat low.

Use and management (subgroup 2I).—All of this soil is in sagebrush and grass. It is poorly suited to dry-farmed grains. Under irrigation, oats, barley, wheat, peas, and vetch should do fairly well.

Lamonta sandy clay loam, shallow, eroded, 3 to 7 percent slopes (Lsb).—This gently sloping or undulating soil occurs near Juniper Butte and Haystack Butte. From much of the acreage, one-fourth or more of the original surface soil has been removed by water or wind.

Use and management (subgroup 2I).—Most of this soil is in sagebrush and grass. A small acreage that was formerly cropped is in crested wheatgrass or annual grasses. In use suitability this soil is similar to Lamonta sandy clay loam, 0 to 3 percent slopes, but its need for additions of organic matter is greater.

Lamonta sandy clay loam, shallow, eroded, 7 to 12 percent slopes (Lsc).—This sloping or rolling soil occurs north of Juniper Butte and northeast and northwest of Haystack Butte. Runoff is slight to moderate. Much of this soil has lost one-fourth or more of the original surface soil through erosion. Unlike the typical Lamonta sandy clay loam, this soil is only about 16 inches or a little less in depth to the underlying rock, and in places it is noncalcareous or only slightly calcareous.

Use and management (subgroup 2I).—Much of this soil is in sagebrush and grass. A small acreage was once cropped but is now in crested wheatgrass or annual grasses. Because the water-holding capacity is somewhat low, this soil is poorly suited to dry-farmed grain. It is better suited to crested wheatgrass grown for grazing. Under irrigation, this soil would be fairly well suited to oats, barley, wheat, peas, and vetch. Because of the erosion hazard it would be better suited to grass-legume pasture than to crops.

Lamonta sandy clay loam, stony, 0 to 3 percent slopes (Lsd).—Except for its finer textured surface soil, this soil is similar to Lamonta loam, stony, 0 to 3 percent slopes. Most of it is too stony to be tilled. A few areas are less stony.

Use and management (group 6).—Almost all of this soil is in its natural vegetation. The less stony areas could be cleared of stones and made suitable for cultivation, preferably under irrigation. In use suitability and management needs this soil is similar to Lamonta loam, stony, 0 to 3 percent slopes. If not irrigated, it seems best suited to controlled grazing. If irrigated, it should be well suited to permanent grass-legume pasture.

Lamonta sandy clay loam, stony, 3 to 7 percent slopes (Lse).—This soil is gently sloping or undulating. It is more likely to erode under irrigation than Lamonta loam, stony, 0 to 3 percent slopes. Most of it is too stony to be tilled. Included are a few areas that are moderately eroded. Such areas are shown on the soil map by erosion symbols.

Use and management (group 6).—Most of this soil is in sagebrush and grass. In a few places, it would be practicable to remove the stones and cultivate this soil, if it could be irrigated. In use suitability and management needs this soil is similar to Lamonta loam, stony, 0 to 3 percent slopes.

Lamonta sandy clay loam, stony, 7 to 12 percent slopes (Lsl).—Because of its stronger slopes, this soil is more likely to erode under irrigation than Lamonta loam, stony, 0 to 3 percent slopes. Most of it is too stony to be tilled. Included are about 60 acres that are moderately eroded.

Use and management (group 6).—Most of this soil is in sagebrush and grass. In a few places, it might be practicable to remove the stones and cultivate this soil, preferably under irrigation. In use suitability and management needs, this soil is similar to Lamonta loam, stony, 0 to 3 percent slopes.

Lamonta sandy clay loam, stony, 12 to 20 percent slopes (Lso).—Enough stones occur on and in this moderately steep or hilly soil to prevent ordinary tillage. Included are about 130 acres where the surface soil is loam or heavy loam. Also included are 90 acres that are moderately eroded.

Use and management (group 6).—Almost all of this soil is under its natural cover. Because of the strong slopes, the difficulty of spreading water evenly, and the erosion hazard, it is not practicable to clear this soil of stones even if it were to be irrigated.

Madras loam

Madras loam generally occurs on level to somewhat rolling upland plains where the normal annual precipitation is 8.5 to 10 inches. The natural vegetation consisted mainly of big sagebrush, bunchgrasses, rabbitbrush, annual grasses, scattered junipers, and associated herbs.

Madras loam has developed from material weathered from partly consolidated sandstone, agglomerate, and other sedimentary or old water-laid materials of the Dalles formation. Most of this material is of volcanic origin. The sandstone and agglomerate are dominant. They are mixed with rhyolitic and other acidic igneous material as well as with andesitic and other more basic materials. The upper part of the soil may contain some fine pumice, volcanic ash, and windblown silt.

Madras loam is associated with Agency, Era, and Lamonta soils. It differs from Agency loam in having a limy siliceous hardpan or caliche layer in the lower subsoil. In texture and compactness the subsoil of Madras is intermediate between that of the Era and that of the Lamonta soils.

Typical profile (fig. 4):

0 to 9 inches, light brownish-gray to grayish-brown slightly hard loam; very fine granular structure; when moist, very dark grayish brown and friable; neutral.

9 to 12 inches, brown to grayish-brown, slightly hard heavy loam or light clay loam; weak fine granular to subangular blocky structure; when moist, dark grayish brown or slightly darker; neutral or mildly alkaline.

12 to 22 inches, brown noncalcareous clay loam grading to grayish-brown or pale brown; breaks into hard medium and fine subangular blocky aggregates that are somewhat coated with colloid; small to moderate number of fine pores; when moist, dark grayish brown to dark brown and firm; mildly to moderately alkaline.

22 to 25 inches, brown or pale-brown to light yellowish-brown hard clay loam or gravelly clay loam; calcareous in most places.

25 to 33 inches, white, pinkish-white, light-gray, or very pale brown, strongly cemented or indurated hardpan or caliche consisting, in most places, of tuffaceous or pumiceous sandstone or agglomerate cemented by lime and siliceous material; normally consists of two or more plates; plates have a very dense or glazed film on top, and may have miniature stalactites on their lower sides; inside of plates may be either calcareous or noncalcareous; commonly much lime between plates and in cracks; may or may not be broken in hands.

33 inches +, partly consolidated tuffaceous or pumiceous sandstone or agglomerate.

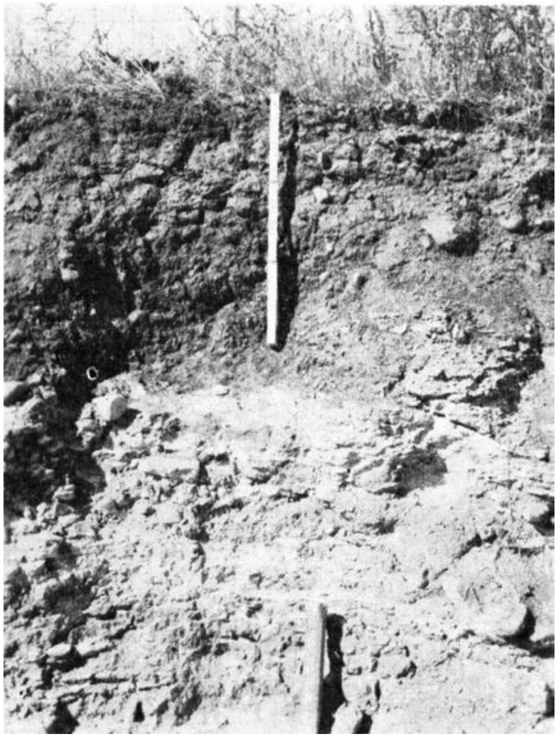

Figure 4.—**Madras loam east of Culver, showing moderately developed subsoil over a limy hardpan. This soil has developed mainly from material weathered from partly consolidated tuffaceous sandstone and agglomerate and small quantities of fine pumice and wind-borne silt.**

Small quantities of light yellowish-brown or very pale brown pumice particles are common. These particles are the size of fine and medium sand. In most places, there are a few red and reddish-brown subangular pebbles of rhyolite on the surface and in the upper part of the soil. Most of the pebbles are less than 1 inch in diameter. Pebbles are generally more numerous and larger in the lower subsoil. In places, there are brown, light yellowish-brown, and olive-brown pebbles and a few pebbles of quartz. In the undisturbed soil, the upper ¾ inch may be vesicular and the next lower 3 inches may be platy. The surface soil is rather low in organic matter and nitrogen.

Drainage is moderate through the surface soil, moderate to somewhat slow through the upper subsoil, and very slow through the hardpan. The hardpan commonly is almost impermeable to water and roots, but some water passes through fissures, cracks, discontinuous plates, or holes. In some flats or swales the pan may be nearly impermeable over wide areas. Excessive irrigation or runoff from higher areas may cause the subsoil in such places to become waterlogged. These areas may become saline, although this soil normally is nonsaline and nonalkali.

Madras loam, 0 to 3 percent slopes (Ma).—This soil occurs in Jefferson County in relatively undissected upland plains and in the more level parts of dissected plains. It occupies much of the Agency Plains. Runoff is slow, and water erosion is slight. If the soil is not protected by vegetation, some wind erosion may occur.

In some flats or swales, sizable areas are underlain by the nearly impermeable hardpan. In these places, excessive irrigation and runoff from higher areas may result in waterlogging of the subsoil and eventually in the accumulation of salts.

Use and management (subgroup 2A).—Almost all of this soil is used for dry-farmed small grain. A small acreage is under natural vegetation and is grazed. About 42 percent is used for wheat, 1 percent for barley, and 5 percent for small grains cut for hay. An area equal to the cultivated area is summer fallowed.

Because it is somewhat shallow and receives little rainfall, this soil is only moderately to poorly suited to dry-farmed grain. The normal yield of winter wheat is about 11 bushels an acre, but yields range from about 4 to 16 bushels, depending mainly on the amount and distribution of rainfall. Average yields of spring wheat are a little less.

Much of this soil will be irrigated under the Deschutes Irrigation Project. The principal crops probably will be alfalfa, potatoes, oats, barley, and wheat; Ladino, alsike, and red clovers for hay and seed; and perhaps peas and vetch for seed. Because the subsoil is clay loam, this soil is not well suited to potatoes. Alfalfa, red clover, alsike clover, and other deep-rooted crops should do fairly well, but the hardpan will limit the growth of their roots. This soil should be well suited to Ladino clover grown for seed, at least until weeds and volunteer clovers spread.

Madras loam, 3 to 7 percent slopes (Mc).—This gently sloping or undulating soil occurs in the somewhat dissected upland of Jefferson County. Large areas lie northeast of Madras. Runoff from rainfall is rather slow, but runoff from irrigation would be more rapid. The erosion hazard under irrigation is moderate. The workability is very good.

Use and management (subgroup 2B).—About 75 to 85 percent of this soil is used for dry-farmed small grains, mostly wheat, and a small part is in sagebrush and grass. A few tracts that have been cropped are now in crested wheatgrass and cheatgrass. Average yields are slightly less than those on Madras loam, 0 to 3 percent slopes.

Much of this soil will be irrigated under the Deschutes Irrigation Project. Irrigating will present little or no difficulty. This soil is in the same management subgroup as Agency loam, 3 to 7 percent slopes.

Madras loam, 7 to 12 percent slopes (Me).—This sloping or rolling soil occurs in Jefferson County in several widely scattered tracts. Runoff from rainfall is moderate to low, but the erosion hazard under irrigation would be high. The workability is good.

The hardpan in this soil is generally less strongly cemented than that in the more nearly level Madras loams. Included in this mapping unit is a tract of about 35 acres that has a surface soil of heavy loam or light clay loam. This tract lies south of Haystack Butte.

Use and management (subgroup 2C).—About 36 percent of this soil is under sagebrush and grass, and about 27 percent is used for dry-farmed grains, chiefly wheat. Most of the rest has been cropped but is now in crested wheatgrass or cheatgrass. Yields are slightly lower than on the more nearly level Madras loams.

A considerable part of this soil probably will be irrigated. It will be difficult to control water and distribute it evenly, particularly on row crops. This soil is poorly suited to potatoes and other row crops. It is fairly well suited to sod and close-growing crops. If possible, this soil should be kept in grass-legume pasture.

Madras loam, eroded, 0 to 3 percent slopes (Mb).—This soil has been moderately eroded, chiefly by wind; much of it has lost one-fourth or more of the original surface soil. In places, deep plowing may turn up some of the subsurface layer or upper subsoil. The surface layer is 2 to 4 inches thinner than that of Madras loam, 0 to 3 percent slopes, and the soil is slightly less fertile.

Use and management (subgroup 2A).—Almost all of this soil is used for dry-farmed wheat. Yields are low.

A large part of this soil will be irrigated under the Deschutes Irrigation Project. In use suitability and management needs this soil is similar to Madras loam, 0 to 3 percent slopes, but it needs larger additions of organic matter and, for potatoes and other row crops, a little more nitrogen.

Madras loam, eroded, 3 to 7 percent slopes (Md).—This gently sloping or undulating soil has been moderately eroded by water or wind, or both. Much of it has lost one-fourth or more of the original surface soil. In places, deep plowing may turn up some of the subsurface layer or upper subsoil. The surface layer is 2 to 4 inches thinner than that of Madras loam, 3 to 7 percent slopes, and the soil is slightly less fertile. The workability is good.

Use and management (subgroup 2B).—In use and management this soil is similar to Madras loam, 3 to 7 percent slopes, but it needs more organic matter and more nitrogen fertilizer.

Much of this soil will be irrigated. It will be slightly difficult to irrigate. The erosion hazard under irrigation will be moderate.

Madras loam, eroded, 7 to 12 percent slopes (Mf).—This sloping or rolling soil occurs in the upland plains northeast of Madras. It has been moderately eroded by water or wind; from much of it one-fourth or more of the original surface soil has been removed. Its surface layer is 2 to 5 inches thinner than that of Madras loam, 7 to 12 percent slopes, and its fertility is slightly lower. The workability is good.

Use and management (subgroup 2C).—Nearly one-fourth of this soil is in sagebrush and grass. About 70 percent is used for dry-farmed grain, chiefly wheat. Yields are low.

Much of this soil probably will be irrigated. It will be difficult to irrigate, and the erosion hazard will be high. It should be kept in grass-legume pasture much of the time. In use suitability and management needs this soil is similar to Madras loam, 7 to 12 percent slopes, but it needs more organic matter and nitrogen.

Madras loam, over sandstone, 0 to 3 percent slopes (Mg).—This soil occurs in Jefferson County in nearly level upland plains. Large tracts lie southwest of Juniper Butte. This soil is much like typical Madras loam, but it does not have a hardpan in the subsoil. Instead, it has a layer of partly consolidated sandstone or agglomerate, in most places very weakly cemented by lime. Here and there the layer is cemented by siliceous material, and is noncalcareous or only slightly calcareous. In many places the subsoil is light clay loam or heavy loam. It contains a little more light-colored pumice sand than the subsoil of the typical Madras loam and, in most places, is more permeable to roots and water.

Use and management (subgroup 2A).—About 30 percent of this soil is under sagebrush and grass and about 15 percent is used for dry-farmed grain. Most of the rest has been cropped, but is now in crested wheatgrass or annual grasses. Yields are low.

Much of this soil will be irrigated. In use suitability and management needs it is similar to Madras loam, 0 to 3 percent slopes, but its subsoil is less likely to be waterlogged, and it is better suited to alfalfa, red clover, alsike clover, and other deep-rooted crops.

Madras loam, over sandstone, 3 to 7 percent slopes (Mk).—This soil differs from Madras loam, over sandstone, 0 to 3 percent slopes, in being gently sloping or undulating. The workability is very good.

Use and management (subgroup 2B).—About 43 percent of this soil is used for dry-farmed grain and 10 percent is in sagebrush and grass. Most of the rest has been cropped but is now in crested wheatgrass or annual grasses. Yields are low.

Much of this soil will be irrigated. It will be slightly difficult to irrigate, and the erosion hazard in cultivated areas will be moderate. This soil is suited to the same uses as Agency loam, 0 to 3 percent slopes, and has similar management needs.

Madras loam, over sandstone, eroded, 0 to 3 percent slopes (Mh).—This soil is moderately eroded; about one-fourth of the original surface soil has been removed, chiefly by wind.

This soil is in management subgroup 2A. Almost all of it is used for dry-farmed grain, chiefly wheat. Yields are low. In use suitability and management needs this soil is similar to Madras loam, over sandstone, 0 to 3 percent slopes, but it needs slightly larger additions of organic matter.

Madras loam, over sandstone, eroded, 3 to 7 percent slopes (Ml).—This soil has lost one-fourth or more of the original surface soil through water and wind erosion. It is slightly difficult to irrigate without causing erosion. Included is a tract of 35 acres that has slopes of 7 to 12 percent, and is uneroded or only slightly eroded.

Use and management (subgroup 2B).—About 45 percent of this soil is used for dry-farmed grain and 20 percent is in sagebrush and grass. The rest is in cheatgrass or crested wheatgrass. In use suitability and management needs this soil is similar to Agency loam, 3 to 7 percent slopes.

Madras loam, stony, 0 to 3 percent slopes (Mm).—Most of this soil is too stony to be tilled. Most of the stones are angular fragments of basalt or other lava rock. They range from a few to 20 inches or more in diameter. Bedrock crops out in places. About 40 percent of this mapping unit has been eroded; such areas are shown on the soil map by erosion symbols.

Use and management (group 6).—Almost all of this soil is in sagebrush and grass and is grazed. The grazing capacity is low; about 10 acres are needed to graze a cow for 1 month.

Because of the stones, this soil is not suitable for crops. Some areas than can conveniently be irrigated should be suited to grass-legume pasture. The carrying capacity of pastures could be increased by applying sulfur and nitrogen and by grazing in rotation.

Madras loam, stony, 3 to 7 percent slopes (Mn).—All of this sloping or undulating soil is in Jefferson County. It is too stony to be tilled. It has somewhat more rapid runoff than Madras loam, stony, 0 to 3 percent slopes, and is erodible unless protected by vegetation. About 42 percent of this mapping unit is moderately eroded.

This soil is in management group 6. In use and management it is similar to Madras loam, stony, 0 to 3 percent slopes, but it is more difficult to irrigate for permanent pasture.

Madras loam, stony, 7 to 12 percent slopes (Mo).—All of this sloping or rolling soil occurs in Jefferson County. It is too stony to be tilled. It has more rapid runoff than Madras loam, stony, 0 to 3 percent slopes, and is more likely to erode if not protected by vegetation. About 45 percent of this mapping unit has been moderately eroded.

This soil is in management group 6. In use and management it is similar to Madras loam, stony, 0 to 3 percent slopes, but it is more difficult to irrigate for permanent pasture. Some areas of this soil may not be suitable for irrigated pasture.

Madras loamy sand

This soil occurs on the upland plains in the southern part of Jefferson County and the northern part of Deschutes County. It is coarser textured than Madras loam, and in some areas the surface soil contains a larger percentage of light-colored pumice particles the size of fine and medium sand. The cemented layer is less limy, thinner, and in most places more weakly cemented. This soil is less fertile than Madras loam and lower in water-holding capacity. Junipers are more prominent in the natural vegetation, particularly south of the Crooked River.

Representative profile:

0 to 9 inches, light brownish-gray to grayish-brown soft loamy sand; single grain; when moist, very dark grayish brown and very friable; about neutral in reaction.

9 to 13 inches, brown to grayish-brown soft sandy loam; single-grain structure; mildly alkaline.

13 to 21 inches, brown hard sandy clay loam or heavy loam; subangular blocky structure; mildly or moderately alkaline and noncalcareous.

21 to 25 inches, weakly to strongly cemented, tuffaceous or pumiceous sandstone or agglomerate; much white lime, particularly as coatings above and below the layer and in cracks.

25 inches+, partly consolidated tuffaceous or pumiceous sandstone or agglomerate.

In most places, a few red and reddish-brown subangular pebbles of rhyolite are on the surface and in the soil; commonly they are more numerous and larger in the lower subsoil. Drainage is rapid through the surface soil, moderate through the upper subsoil, very slow or slow through the cemented layer, and slow through the substratum. In places, the subsoil is coarser textured than typical.

Two phases of this soil are mapped.

Madras loamy sand, over sandstone, 3 to 7 percent slopes (Mp).—This soil is gently sloping or undulating. Runoff from rainfall is low, but the erosion hazard under irrigation is moderate. This soil is slightly difficult to irrigate. The water-holding capacity is low. The workability is very good. Included are 11 acres that have slopes of 0 to 3 percent. This acreage is easier to irrigate and better suited to crops than the rest of this mapping unit.

Use and management (subgroup 2B).—Sagebrush and grass, with junipers in places, cover almost half of this soil. About one-third is used for crops and pasture. Most of the rest has been cropped but is now in grass. Dry-farmed grain is grown north of the Crooked River, and the areas south of the river are irrigated.

This soil is only fair for crops. It is not well suited to dry-farmed grain. It is poorly suited to irrigated row crops. The irrigated areas should be kept in pasture, hay, or close-growing crops as much of the time as possible. Additions of manure and other organic matter are beneficial.

Madras loamy sand, over sandstone, eroded, 3 to 7 percent slopes (Mr).—This soil has been moderately eroded by water and wind. It is in management subgroup 2B. About 85 percent of it is used for dry-farmed grain, chiefly wheat. A few acres are in natural vegetation. Yields are low. In use suitability and management needs, this soil is similar to Madras loamy sand, over sandstone, 3 to 7 percent slopes.

Madras sandy loam

Almost all of the Madras sandy loam in the Area occurs in Jefferson County; a small acreage lies in the northern part of Deschutes County. This soil is similar to Madras loam except that it is sandier and a little less fertile and has more rapid drainage through the surface soil. In places, this soil contains more light-colored pumice sand than Madras loam.

Representative profile:

0 to 9 inches, light brownish-gray to grayish-brown soft or slightly hard sandy loam; noncalcareous; single grain; when moist, very dark grayish brown and very friable; neutral reaction.

9 to 13 inches, brown to grayish-brown, slightly hard, noncalcareous heavy sandy loam, loam, or light sandy clay loam; weak fine granular or indistinct fine subangular blocky structure; when moist, dark grayish brown or slightly darker; neutral or mildly alkaline reaction.

13 to 24 inches, brown sandy clay loam, clay loam, or light clay loam, grading to pale brown; noncalcareous; breaks into hard medium and fine subangular blocky aggregates that are thinly coated with colloid; lower 2 or 3 inches may be pale brown or light yellowish brown and calcareous.

24 to 31 inches, white, pinkish white, light gray, or very pale brown strongly cemented or indurated hardpan or caliche, in most places consisting of tuffaceous or pumiceous sandstone or agglomerate cemented by lime and siliceous material; layer usually consists of plates or lenses that have a very dense or glazed film on top and, in places, miniature stalactites on the lower side; plates may be either calcareous or noncalcareous on the inside but lime occurs commonly between plates and in cracks; may or may not be broken in hands.

31 inches +, partly consolidated tuffaceous or pumiceous sandstone or agglomerate.

This soil contains a few red and reddish-brown subangular pebbles of rhyolite, most of them less than 1 inch in diameter. They are normally more numerous and larger in the lower subsoil. In places there are brown, light yellowish-brown, and olive-brown pebbles and a few pebbles of quartz. This soil is low in organic matter and nitrogen.

Drainage is moderate to rapid through the surface soil, moderate through the upper subsoil, and very slow through the hardpan. The hardpan typically is practically impermeable to water and roots, but water passes through fissures, cracks, discontinuous plates, or holes. The soil is naturally nonsaline and nonalkali.

To show variations in slope, depth, stoniness, underlying material, and erosion, 26 phases of this soil are mapped.

Madras sandy loam, 0 to 3 percent slopes (Ms).—This soil occurs in Jefferson County, chiefly on the nearly level upland plains. Runoff is slow. Water erosion is negligible or only slight in nonirrigated areas, but wind erosion may occur in places.

Use and management (subgroup 2A).—Most of this soil is used for dry-farmed wheat. A small part remains in its natural cover and is grazed. A few areas are in crested wheatgrass. In use and management this soil is similar to Madras loam, 0 to 3 percent slopes, but yields are slightly lower.

Most of this soil will be irrigated. The irrigated areas should be used and managed like Madras loam, 0 to 3 percent slopes, but this soil apparently will need larger additions of organic matter, nitrogen, and phosphorus. Yields of potatoes may be the same on this soil, but yields of other crops are expected to be slightly lower. This soil requires lighter and more frequent irrigations; the head of water should be larger and the irrigation runs shorter. Excessive irrigation may waterlog the subsoil.

Madras sandy loam, 3 to 7 percent slopes (Mu).—This gently sloping or undulating soil occurs in Jefferson County, mainly in the somewhat dissected upland plains. Runoff from rainfall is rather slow. Under irrigation, runoff would be more rapid and the erosion hazard would be moderate. The workability is very good.

Use and management (subgroup 2B).—Much of this soil is used for dry-farmed grain, chiefly wheat. Yields are low. A few areas are still in sagebrush and grass and a few have been seeded to crested wheatgrass. This soil is only fair for irrigated crops, but much of it will be irrigated. It is in the same management subgroup as Agency loam, 3 to 7 percent slopes, but it needs more organic matter, nitrogen, and phosphorus.

Madras sandy loam, 7 to 12 percent slopes (My).—This sloping or rolling soil occurs in the dissected upland plains in Jefferson County. It is slightly shallower than the more nearly level Madras sandy loams, and in most places the hardpan is only weakly to strongly cemented. Runoff from rainfall is low to moderate.

Use and management (subgroup 2C).—About 55 percent of this soil is in sagebrush and grass, and 20 percent is used for dry-farmed grain. Much of the rest has been seeded to crested wheatgrass, to which this soil is well suited.

A considerable part of this soil probably will be irrigated. In use and management it is similar to Madras loam, 7 to 12 percent slopes, but irrigation runs should be shorter on this soil and water should be applied more often and in smaller amounts.

Madras sandy loam, deep over sandstone, 0 to 3 percent slopes (Mea).—This soil differs from Madras sandy loam, 0 to 3 percent slopes, in having in the lower subsoil, normally at depths of 3 to 4 feet, a layer that is only weakly cemented. This layer is more permeable to water and roots than the cemented layer of Madras sandy loam, 0 to 3 percent slopes. Furthermore, this soil may contain more pumice sand, and the subsoil may be slightly lighter in texture and may contain some lime a few inches above the cemented layer.

Runoff is very low and water erosion is negligible, but this soil may be eroded by wind. This soil is normally well drained, but excessive irrigation and runoff from higher areas may cause an accumulation of water. Such an area occurs near Terrebonne; it is shown on the soil map by marsh symbols. Excessive soluble salts may accumulate in these inadequately drained areas.

Use and management (subgroup 2A).—About 85 percent of this soil is used for crops. North of the Crooked River this soil is used for dry-farmed crops, and south of the river it is used for irrigated crops and pasture. About 10 percent is in sagebrush and grass.

If irrigated properly, this is one of the better soils of the Area for crops and pasture. It is deep enough for alfalfa and clover roots. The water-holding capacity is somewhat high. Areas that are adequately drained produce high yields.

Madras sandy loam, deep over sandstone, 3 to 7 percent slopes (Meb).—This soil occurs in Jefferson County and in the northern part of Deschutes County. It is gently sloping or undulating. It has slightly higher runoff than Madras sandy loam, deep over sandstone, 0 to 3 percent slopes, particularly under irrigation. This soil is easy to slightly difficult to irrigate. The erosion hazard under irrigation is moderate. This soil is well drained, and ponding is not likely to occur.

Use and management (subgroup 2B).—About 20 percent of this soil is used for irrigated and dry-farmed crops. Most of the rest is in sagebrush and grass. This uncultivated area lies on high benches below the main upland plains in the Deschutes River canyon, where irrigation may not be feasible.

This soil is in the same management subgroup as Madras sandy loam, 3 to 7 percent slopes, but it is better suited to alfalfa and clover.

Madras sandy loam, deep over sandstone, eroded, 3 to 7 percent slopes (Mec).—Most of this soil occurs in Jefferson County; a small acreage is in Deschutes County near Terrebonne. This soil has been moderately eroded by water and wind.

Use and management (subgroup 2B).—About 15 percent of this soil is in sagebrush and grass. Nearly 50 percent is used for crops. The rest is idle or is in annual grasses. The area in Jefferson County is used for dry-farmed grain and that near Terrebonne has been irrigated.

This soil is in the same management subgroup as Madras sandy loam, 3 to 7 percent slopes, but it is better suited to alfalfa and clover. This soil, however, needs slightly more organic matter and nitrogen.

Madras sandy loam, eroded, 0 to 3 percent slopes (Mt).—All of this soil is in Jefferson County. Much of it has lost one-fourth or more of the original surface soil through erosion, chiefly wind erosion.

Use and management (subgroup 2A).—In use and management, under both dry farming and irrigated farming, this soil is similar to Madras sandy loam, 0 to 3 percent slopes, but it needs larger additions of organic matter and nitrogen.

Most of this soil probably will be irrigated. Yields should be almost as high as those on Madras sandy loam, 0 to 3 percent slopes.

Madras sandy loam, eroded, 3 to 7 percent slopes (Mv).—From most of this soil, erosion has removed about one-fourth or more of the original surface soil. This soil is in the same management subgroup as Madras sandy loam, 3 to 7 percent slopes, but it needs more organic matter and nitrogen. Yields are slightly lower.

Madras sandy loam, eroded, 7 to 12 percent slopes (Mz).—This soil is moderately eroded; 25 to 75 percent of the original surface soil has been removed.

Use and management (subgroup 2C).—About one-fourth of this soil is in sagebrush and grass. The rest is used for dry-farmed grain. Yields are low. In use and management this soil is similar to Madras sandy loam, 7 to 12 percent slopes, but it needs larger additions of organic matter and nitrogen.

Madras sandy loam, over sandstone, 0 to 3 percent slopes (Med).—This nearly level soil is widely distributed, mostly in Jefferson County; a few tracts lie near Terrebonne. This soil differs from Madras sandy loam, 0 to 3 percent slopes, mainly in having a less strongly cemented, more permeable lower subsoil. This soil contains less white lime. The weakly cemented lower subsoil normally can be broken with the hands. The upper subsoil may be slightly coarser in texture and less compact. The upper part of this soil contains considerably more pumice. Ponding is less likely than on Madras sandy loam, 0 to 3 percent slopes.

Included are some areas in which the cemented layer is partly consolidated sandstone or agglomerate that has some lime in seams or fissures.

Use and management (subgroup 2A).—Much of this soil is used for crops, a small part is in natural vegetation, and a small part is used for crested wheatgrass. North of the Crooked River this soil is dry-farmed; south of the river the cropland and pasture are irrigated.

In use and management this soil is similar to Madras sandy loam, 0 to 3 percent slopes, but it is slightly better suited to alfalfa. If potatoes are grown, additions of fertilizer and organic matter are needed.

Madras sandy loam, over sandstone, 3 to 7 percent slopes (Meh).—Most of this soil occurs in Jefferson County; a few scattered tracts lie near Terrebonne. This gently sloping or undulating soil is similar to Madras sandy loam, over sandstone, 0 to 3 percent slopes, but runoff is slightly more rapid, and the erosion hazard under irrigation is moderate. This soil is slightly difficult to irrigate.

Use and management (subgroup 2B).—Most of this soil is used for crops. The acreage north of the Crooked River is used for dry-farmed grain; that south of the river is used for irrigated crops and pasture.

Much of the area north of the Crooked River will be irrigated under the Deschutes Irrigation Project. In use and management this soil is similar to Madras sandy loam, 3 to 7 percent slopes, but it is better suited to potatoes and alfalfa.

Madras sandy loam, over sandstone, 7 to 12 percent slopes (Meo).—Most of this soil occurs in Jefferson County; a small acreage lies in the northern part of Deschutes County. This soil is similar to Madras sandy loam, over sandstone, 0 to 3 percent slopes, but, because it is sloping or rolling, runoff is more rapid and the erosion hazard under irrigation is higher. This soil is difficult to irrigate. The workability is good. Included are about 15 acres in which the surface soil is a loamy sand.

Use and management (subgroup 2C).—About 35 percent of this soil is in sagebrush and grass and 10 percent is used for dry-farmed grain, chiefly wheat. Most of the rest has been cropped but is now in crested wheatgrass.

A considerable part of this soil probably will be irrigated. It should be used and managed in about the same way as Madras loam, 7 to 12 percent slopes.

Madras sandy loam, over sandstone, 12 to 20 percent slopes (Mla).—This moderately steep or hilly soil occurs in Jefferson County. In most places the lower subsoil is less strongly cemented, contains less lime, and is more permeable to roots and water than the subsoil of Madras sandy loam, over sandstone, 0 to 3 percent slopes. In places this soil may be noncalcareous throughout the profile. In many places the upper subsoil is loam or light sandy clay loam and is only slightly hard. Included are about 25 acres where the surface soil is loam.

Runoff from rainfall is moderate to slight, but the erosion hazard under irrigation is very high. This soil is very difficult to irrigate. Its workability is fair.

Use and management (subgroup 2D).—About 20 percent of this soil is in sagebrush and grass. Nearly 40 percent is used for dry-farmed grain, mainly wheat. A little is in crested wheatgrass. This soil is poor for dry-farmed grain. It is better suited to crested wheatgrass for grazing.

This soil is poorly suited to irrigated row crops. If irrigated, it should remain in permanent grass-legume pasture and should be plowed only to renew a stand.

Madras sandy loam, over sandstone, eroded, 0 to 3 percent slopes (Mef).—This soil occurs in Jefferson County. It is moderately eroded; about one-fourth or more of the original surface soil has been removed, chiefly by wind.

Use and management (subgroup 2A).—About 9 percent of this soil is in sagebrush and grass. Nearly all the rest is used for dry-farmed grain, chiefly wheat. Yields of grain are low. A few acres are in crested wheatgrass.

In use and management this soil is similar to Madras loam, over sandstone, 0 to 3 percent slopes, except that it needs somewhat larger additions of organic matter and nitrogen. Most of this soil will be irrigated.

Madras sandy loam, over sandstone, eroded, 3 to 7 percent slopes (Mel).—Almost all of this soil occurs in Jefferson County; a few small tracts are in the northern part of Deschutes County. This soil has been moderately eroded; from much of it water and wind erosion have removed one-fourth or more of the original surface soil.

Use and management (subgroup 2B).—About one-fourth of this soil is under its natural cover. Nearly all the rest is used for crops. The cultivated areas north of the Crooked River are used for dry-farmed grain, mostly wheat; those south of the river are used for irrigated crops and pasture. This soil is suitable for the same uses as Madras sandy loam, over sandstone, 3 to 7 percent slopes, and has similar management needs.

Madras sandy loam, over sandstone, eroded, 7 to 12 percent slopes (Mes).—Almost all of this soil occurs in Jefferson County in the dissected upland plains. This soil has been moderately eroded; from much of its area 25 to 75 percent of the original surface soil has been removed. A few shallow gullies have formed. In some places deep plowing will turn up some of the subsoil. The workability is good. Included are about 25 acres in which the surface soil is a loamy sand.

Use and management (subgroup 2C).—About one-third of this soil has a cover of sagebrush and grass. Nearly one-third is used for dry-farmed grain. Part of the rest has been sown to crested wheatgrass. Yields of grain are low.

In use suitability and management needs this soil is similar to Madras loam, 7 to 12 percent slopes. It should be irrigated by the corrugation method or by flooding from contour laterals. The irrigation runs should be short and the head of water moderate.

Madras sandy loam, over sandstone, eroded, 12 to 20 percent slopes (Mlc).—This moderately steep or hilly soil occurs in the dissected plains of Jefferson County. It has lost 25 to 75 percent of its original surface soil through erosion. A few acres of this mapping unit have slopes of 20 to 25 percent. Also included are 40 acres of loam that has higher fertility and water-holding capacity than the typical soil.

Use and management (subgroup 2D).—Most of this soil has its natural vegetation. About 9 percent is used for dry-farmed grains and 15 percent has been sown to crested wheatgrass.

In use and management this soil is similar to Madras sandy loam, over sandstone, 12 to 20 percent slopes. It is well suited to crested wheatgrass.

Madras sandy loam, shallow over sandstone, 0 to 3 percent slopes (Mld).—This soil occurs in Jefferson County and in the northern part of Deschutes County. It differs from Madras sandy loam, 0 to 3 percent slopes, chiefly in being shallower to the cemented layer, which in most places occurs at a depth of about 16 inches or less. In this soil the layer is weakly to strongly cemented. In places there is little or no lime. The water-holding capacity is low and the root zone shallow. Included are a few acres in Jefferson County that have been moderately eroded by wind.

Use and management (subgroup 2I).—About 50 percent of this soil is used for crops, and slightly more than 30 percent is in sagebrush and grass. Some of the rest has been sown to crested wheatgrass. The cropped areas in Deschutes County are irrigated; those in Jefferson County are dry-farmed.

This shallow soil is poorly suited to dry-farmed grain. Yields are very low. One of the best uses for this soil is controlled grazing of crested wheatgrass.

Much of this soil probably will be irrigated. It is only fair to poor for irrigated crops, but it is fairly well suited to permanent grass-legume pasture. This soil is poorly suited to alfalfa, alsike clover, red clover, and other deep-rooted crops, even though roots may penetrate the cemented layer in places. It is fairly well suited to potatoes, small grains, and probably peas, vetch, and Ladino clover. It is well suited to permanent pasture.

Deep cuts should be avoided when this soil is graded and leveled. To avoid waterlogging the subsoil, irrigations should be light and frequent.

Madras sandy loam, shallow over sandstone, 3 to 7 percent slopes (Mle).—Most of this soil occurs in the southern part of Jefferson County; a small part lies in the northern part of Deschutes County. This soil differs from Madras sandy loam, over sandstone, 3 to 7 percent slopes, in being only about 16 inches or less to the cemented layer of the subsoil. In places there is little or no lime. The water-holding capacity of this soil is low and the root zone shallow.

Use and management (subgroup 2I).—Nearly 60 percent of this soil is used for crops, mostly dry-farmed grain; about 20 percent is in sagebrush and grass. Much of the rest has been seeded to crested wheatgrass—a good use. Yields are very low.

Because of its position, probably little of this soil will be irrigated. It is a poor soil for irrigated crops and should be kept in grass-legume pasture much of the time. This soil is better suited to potatoes, small grains, Ladino clover, peas, and vetch than to deep-rooted crops.

Irrigating this soil would be difficult. Deep cuts should be avoided while leveling. It should be irrigated by the corrugation method or by flooding from contour laterals. Small amounts of water should be applied at short intervals.

Madras sandy loam, shallow over sandstone, 12 to 20 percent slopes (Moc).—This soil occurs in Jefferson County. It differs from Madras sandy loam, over sandstone, 12 to 20 percent slopes, mainly in being only about 16 inches or less in depth to the cemented subsoil layer. In places there is little or no lime. The water-holding capacity is low. It is very difficult to irrigate this soil without causing erosion.

Use and management (group 5).—Much of this soil has been cropped but is now in crested wheatgrass. About one-third is in natural vegetation. A small acreage is used for dry-farmed grain. Yields of grain are low.

This soil is very poorly suited to crops. It can be seeded to crested wheatgrass and used for grazing. Grazing should be carefully controlled.

Madras sandy loam, shallow over sandstone, eroded, 3 to 7 percent slopes (Mlo).—This soil occurs in Jefferson County. It has been moderately eroded.

Use and management (subgroup 2I).—About half of this soil is in sagebrush and grass; nearly one-fourth is used for dry-farmed grain. Most of the rest has a growth of crested wheatgrass.

Possibly some of this soil will be irrigated. In use suitability and management needs this soil is similar to Madras sandy loam, shallow over sandstone, 3 to 7 percent slopes, but it needs more organic matter and nitrogen.

Madras sandy loam, shallow over sandstone, eroded, 7 to 12 percent slopes (Mls).—This sloping or rolling soil occurs in Jefferson County. Much of it has lost from 25 to 75 percent of the surface soil through erosion. Because it is 16 inches or less in depth to the cemented subsoil layer, the water-holding capacity is low and the root zone is limited.

Use and management (subgroup 2I).—Almost all of this soil is in sagebrush and grass. This soil is very poorly suited to crops. It does not hold enough moisture to be suitable for dry-farmed grain. Irrigation would be difficult to very difficult because little or no grading is feasible. If irrigated, this soil should be kept in grass-legume pasture.

Madras sandy loam, stony, over sandstone, 0 to 3 percent slopes (Mod).—Most of this soil occurs in Jefferson County, but several tracts lie in the northern part of Deschutes County. This soil differs from Madras sandy loam, over sandstone, 0 to 3 percent slopes, chiefly in containing more stones. Most of these stones are angular fragments of basalt, rhyolite, or other lava. They range from a few to 20 inches or more in diameter. In places bedrock outcrops. In most places the stones are numerous enough to prevent ordinary tillage; in a few places they are less numerous.

Use and management (group 6).—Almost all of this soil is in its natural vegetation. A small acreage has been partly cleared of stones and the soil was cropped, but this acreage was later sown to crested wheatgrass. The carrying capacity of the natural vegetation is low. The stones interfere with preparing the soil for seeding grass.

This soil is not suitable for crops. If it could be irrigated conveniently, it would be suited to permanent grass-legume pasture. The carrying capacity could be increased by applying sulfur and nitrogen, and by dividing the pasture into 3 or 4 tracts to be grazed in rotation.

Madras sandy loam, stony, over sandstone, 3 to 7 percent slopes (Moe).—This soil occurs in Jefferson County and in the northern part of Deschutes County. Except that it is gently sloping or undulating, this soil is very similar to Madras sandy loam, stony, over sandstone, 0 to 3 percent slopes. In most areas this soil contains enough stones to prevent ordinary tillage. Included are about 85 acres from which erosion has removed one-fourth or more of the original surface soil. Such areas are shown on the soil map by erosion symbols.

Use and management (group 6).—Almost all of this soil is in its natural vegetation. In use suitability and management needs this soil is similar to Madras sandy loam, stony, over sandstone, 0 to 3 percent slopes, except that it is more difficult to irrigate evenly.

Madras sandy loam, stony, over sandstone, 7 to 12 percent slopes (Mol).—This soil is similar to Madras sandy loam, stony, over sandstone, 0 to 3 percent slopes, except that it is sloping or rolling and therefore has more rapid runoff. About three-fourths of this mapping unit is moderately eroded.

Use and management (group 6).—Almost all of this soil is in its natural vegetation. About 25 acres is used for dry-farmed grain, and a few areas are in crested wheatgrass. Some of the stones have been removed from these cultivated areas, or the areas may have been originally less stony than the rest of this soil. In use suitability and management needs this soil is similar to Madras sandy loam, stony, over sandstone, 0 to 3 percent slopes, but, because of the stronger slopes, the distribution of water is more difficult. Many areas may not be suitable for irrigated pasture.

Madras sandy loam, stony, over sandstone, 12 to 20 percent slopes (Mos).—This moderately steep or hilly soil occurs in Jefferson County. It is somewhat similar to Madras sandy loam, stony, over sandstone, 0 to 3 percent slopes, but runoff is more rapid. Also, the compact layer may be less cemented, and in places the soil contains little or no lime. About 90 percent of this mapping unit is moderately eroded. Also included are about 40 acres that have 20 to 35 percent slopes.

Use and management (group 6).—Almost all of this soil is in its natural vegetation. A few acres have a growth of crested wheatgrass. This soil is best suited to grazing. Because of the steep slopes, water for irrigated pasture is very difficult to control.

Metolius sandy loam

Almost all of the Metolius sandy loam in the Area occurs in Jefferson County. It occupies nearly level to undulating basins, elongated swales, bottom lands of intermittent streams, and sloping alluvial fans. This soil is normally well drained; it is seldom, if ever, flooded.

The normal annual precipitation is about 8 or 10 inches, except in a few areas southeast of Haystack Butte where the precipitation is slightly higher. The native vegetation consisted chiefly of big sagebrush, bunchgrasses, rabbitbrush, annual grasses, associated herbs, and a few scattered junipers.

This soil apparently has developed from somewhat stratified sandy and loamy alluvial material that contained much light-colored pumice sand of various sizes. Some of the parent material possibly was windblown fine pumice, volcanic ash, and windblown silt.

Representative profile:

0 to 7 inches, light brownish-gray to grayish-brown noncalcareous soft to slightly hard sandy loam; single grain or very weak very fine granular structure; contains moderate to large quantity of light yellowish-brown or very pale brown pumice sand; when moist, very dark grayish brown and very friable; neutral or mildly alkaline.

7 to 14 inches, similar to layer above but grades to pale brown or light yellowish brown.

14 to 23 inches, pale-brown to light brownish-gray noncalcareous slightly hard sandy loam; single grain or very weak coarse subangular blocky structure; contains pumice sand similar to that in surface layer; moderately porous; when moist, dark grayish brown to dark brown and very friable; in places, contains a few hard rounded aggregates as large as 1 inch in diameter; mildly to moderately alkaline.

23 to 47 inches, similar in color to layer above; slightly calcareous, soft or slightly hard, very friable sandy loam; single grain; contains much pumice sand.

47 inches +, similar in color to layer above; stratified, very friable sandy loam, loamy sand, or gravelly sandy material; commonly calcareous.

This soil varies from place to place. In the typical soil no layer that impedes the downward penetration of roots and water occurs above a depth of about 5 feet. Such typical soils occur mainly in the valleys of Mud Spring Creek, Willow Creek, and other intermittent creeks; but even in these valleys this soil has, in places, a thin cemented layer of lime or hardpan at a depth of about 3 feet. In other areas, particularly on alluvial fans and in the basins or swales of the more nearly level upland plains, a layer of less permeable material occurs at a depth of about 3 to 3½ feet. This layer may be a hardpan, or it may consist of partly consolidated sandstone or agglomerate, alluvial loam and silt loam, or, in a few places, clay loam or clay.

This soil is low in organic matter and nitrogen. It is deep and moderately permeable or rapidly permeable. It is normally nonsaline.

To show variations in slope and erosion, seven phases of this soil are mapped.

Metolius sandy loam, 0 to 3 percent slopes (Mta).—This nearly level soil occurs in Jefferson County. Runoff is slow. Excessive irrigation and runoff from higher irrigated soil may cause some areas of this soil to become waterlogged. This is likely to occur where a slowly permeable layer occurs at a depth of 4 or 5 feet or less. A perched water table may form above the slowly permeable layer. Artificial drains may be needed to remove the excess water. Soluble salts may eventually accumulate in these areas. This soil is low in organic matter.

Use and management (subgroup 4A).—Three-fourths or more of this soil is used for dry-farmed grain, chiefly wheat. A small part is in sagebrush and grass. Several areas are in crested wheatgrass or annual grasses. Yields of grain are low. The average yield of winter wheat is about 10 bushels an acre. Yields are slightly higher near Haystack Butte where there is more precipitation.

Most of this soil will be irrigated under the Deschutes Irrigation Project. This should be one of the best soils in the Area for many irrigated crops. About the same kind of crops probably will be grown on this soil as are now grown on Deschutes sandy loam, 0 to 3 percent slopes. These crops include alfalfa, potatoes, oats, barley, wheat; alsike, Ladino, and red clovers for hay and seed; and perhaps vetch and peas for seed.

This soil should be used and managed like Deschutes sandy loam, deep, 0 to 3 percent slopes. The tracts that do not have a hard layer within 5 feet of the surface would be the best irrigated soil in the Area for alfalfa and deep-rooted clover.

In grading and leveling this soil for irrigation, deep cuts can be made. Irrigations can be heavier than on shallower soils and somewhat less frequent.

Metolius sandy loam, 3 to 7 percent slopes (Mtd).—This soil occurs in Jefferson County on gently sloping alluvial fans and in undulating areas of bottom lands. Runoff from rainfall is slow.

Use and management (subgroup 4B).—Much of this soil is used for dry-farmed grain. A small part is in sagebrush and grass. A few areas that were formerly cropped now have a growth of crested wheatgrass or annual grasses. Yields are about the same or a little less than those on Metolius sandy loam, 0 to 3 percent slopes.

A considerable part of this soil will be irrigated. It will be easy or slightly difficult to irrigate, and the erosion hazard will be moderate. In use suitability and management needs this soil will be somewhat similar to Metolius sandy loam, 0 to 3 percent slopes, but yields are expected to be slightly lower. This soil will be somewhat less well suited to potatoes and other row crops.

If this soil is leveled crosswise between strips, the strip-border method of irrigation can be used on the more gentle slopes. On the stronger slopes, the corrugation method or flooding from contour laterials is suitable.

Metolius sandy loam, 7 to 12 percent slopes (Mts).—This soil occurs in several tracts in Jefferson County on rolling alluvial fans, in colluvial areas, or on bottom lands. Runoff from rainfall is rather slow. Included are 55 acres that are moderately eroded; such areas are shown on the soil map by erosion symbols. Also included are about 15 acres in which the surface soil is a loamy sand.

Use and management (subgroup 4C).—About one-third of this soil is used for dry-farmed grain, chiefly wheat. One-fourth is in sagebrush and grass. Much of the rest was formerly cropped but is now in crested wheatgrass or annual grasses. Some of this acreage was seeded under a Federal land utilization project. Yields of grain have been low.

Much of this soil probably will be irrigated. It will be difficult to irrigate, and the erosion hazard will be high. This soil is poorly suited to row crops. It should be kept in alfalfa-grass hay, clover-grass hay, or grass-legume pasture most of the time. This soil apparently is suited to clover grown for seed.

Metolius sandy loam, eroded, 0 to 3 percent slopes (Mtc).—This soil has lost about one-fourth or more of the original surface soil, chiefly through wind erosion. Included are about 120 acres in which the surface soil is a light loam, and about 15 acres in which the surface soil is a loamy sand.

Use and management (subgroup 4A).—In use suitability and management needs this soil is similar to Metolius sandy loam, 0 to 3 percent slopes, but it needs more organic matter and nitrogen.

Metolius sandy loam, eroded, 3 to 7 percent slopes (Mte).—This soil has lost about one-fourth or more of the original surface soil through water and wind erosion. Included are about 20 acres in which the surface soil is a loam and 10 acres in which the surface soil is a loamy sand.

Use and management (subgroup 4B).—In use suitability and management needs this soil is similar to Metolius sandy loam, 3 to 7 percent slopes, but it needs more organic matter and nitrogen.

Metolius sandy loam, terrace position, 0 to 3 percent slopes (Mtl).—This soil occurs in Jefferson County and in the northern part of Deschutes County. It lies in the canyon of the Deschutes River, on terraces and high bottom lands that are 10 to 25 feet higher than the river. Although most areas of this soil adjoin the river, they are not flooded. In places the subsoil is slightly finer textured and more compact than in the typical soil.

Use and management (subgroup 4A).—About 50 percent of this soil is used for crops, 40 percent is in sagebrush and grass, and the rest is used for farmsteads or other purposes. Most of the cropped areas are in dry-farmed grain. A few areas adjoining the river are used for orchards, chiefly peach orchards. To irrigate the orchards, water is pumped from the river and distributed by sprinklers. Peaches can be grown here only because at the bottom of the Deschutes River canyon the growing season is longer than elsewhere in the Area, and the risk of frost damage is less. Some other low-lying tracts could possibly be irrigated by water pumped from the river. It is not likely that any of this soil will be irrigated by gravity under the Deschutes Irrigation Project.

Metolius sandy loam, terrace position, 3 to 7 percent slopes (Mto).—This soil is similar to Metolius sandy loam, terrace position, 0 to 3 percent slopes, except that it is gently sloping or undulating and, therefore, runoff is more rapid and the erosion hazard under irrigation higher.

Use and management (subgroup 4B).—About 70 percent of this soil is in sagebrush and grass; the rest is used for crops and farmsteads. In use and management this soil is similar to Metolius sandy loam, terrace position, 0 to 3 percent slopes, except that it is more likely to erode under irrigation.

Odin clay loam

Odin clay loam occurs in Jefferson County and in the northern part of Deschutes County. It lies in depressions and small basins that do not have natural outlets. It is imperfectly or poorly drained. Most areas of this soil, particularly those in the northern part of Deschutes County, occupy the lower part of extensive undissected plains. Other areas are in small pockets or depressions in lava flows. Most areas have practically no runoff. Most areas have at least a fairly high water table some of the time. A few places may be flooded for short periods. Doubtless some of these areas are imperfectly drained as the result of long periods of irrigation, but many, such as the nonirrigated areas in Jefferson County, probably are naturally inadequately drained.

The natural vegetation probably consisted of grasses, big sagebrush, rabbitbrush, associated herbs, and possibly junipers. Now some areas have a growth of water-loving grasses, sedges, and reeds; a few places have cattails. The normal annual precipitation ranges from 8 to 10 inches.

This soil has formed principally from pumice, which was probably mixed with local alluvium that washed from nearby areas underlain by weathered partly consolidated sandstone or with other waterlaid materials. This material is mixed, but it is mostly from extrusive acid igneous rock sources.

Typical profile:

0 to 7 inches, light brownish-gray or gray hard noncalcareous clay loam; contains some pumice sand; when wet, very dark grayish brown, sticky, and plastic; about neutral in reaction.

7 to 45 inches, light brownish-gray, light-gray, or gray noncalcareous heavy clay loam; contains some pumice sand; massive to indistinct subangular blocky structure; when wet, dark grayish brown, plastic, and sticky; mildly to moderately alkaline; in places a few streaks or mottles of light yellowish brown and very dark gray stains of iron and manganese.

45 inches +, partly consolidated pumiceous or tuffaceous sandstone.

Included are areas that have a loam surface soil and a subsoil of heavy loam or clay loam. In some places the subsoil is clay.

Some of this soil has small pebbles scattered throughout the profile. Here and there a few light yellowish-brown mottles occur in the surface soil as well as in the subsoil. In places a little lime occurs in the lower subsoil or underlying sandstone. This soil is apparently low in organic matter.

Drainage through the soil is generally slow, except where a high water table prevents the downward movement of water. This soil is normally nonsaline, but a slight accumulation of soluble salts occurs in a few places.

Two phases of this soil are mapped.

Odin clay loam, 0 to 3 percent slopes (Oa).—Most of this soil occurs in the northern part of Deschutes County; a few tracts lie in Jefferson County in the western part of the Area. This soil occupies low flats, slight depressions, or small shallow basins in the uplands. Most of these areas have no outlets for surface drainage. In a few places intermittent ponds occur. Some areas have been drained by drilling to the porous layer.

Use and management (subgroup 1K).—About 75 percent of this soil is used for crops or grass-legume pasture. About 8 percent is in natural vegetation. The rest is in cheatgrass or sedges, or it is ponded. In Deschutes County this soil is irrigated, if irrigation is needed, and used for oats, barley, wheat, alsike clover, vetch, and grass-legume pasture. In Jefferson County dry-farmed grain is grown.

This soil is poorly suited to irrigated row crops, especially deep-rooted crops. Unless the soil is adequately drained, it is not suited to alfalfa and red clover. Because of its fine texture, this soil is not suited to potatoes. In most areas oats, wheat, barley, vetch, and alsike clover and Ladino clover grown for hay should do fairly well. This soil is well suited to grass-legume pasture.

Odin clay loam, 3 to 7 percent slopes (Ob).—This soil occurs in one tract, which borders the Deschutes River in the northwestern corner of the area. The tract is part of the alluvial fans and colluvial slopes at the base of the high canyon wall.

On the face of the canyon wall, sandstone, agglomerate, and lava are exposed and, below these, strata of the John Day formation, which consists of volcanic ash and tuff and some clay. The parent material of this soil was a mixture derived from the materials in the canyon wall. Possibly some river sediments were added to the mixture.

This soil differs somewhat from the typical Odin soil but it is included with the Odin series because its total area is small. Drainage is adequate, but apparently water that seeped from the canyon wall has affected this soil. This soil is not flooded. In places the surface soil is grayish brown and contains a moderate amount of organic matter and the lower subsoil is calcareous. The lower subsoil may be moderately or strongly alkaline. The underlying material normally is stratified. It may consist of loam, fine sand, sand, or gravelly material.

Use and management (subgroup 1K).—All of this soil is used for range grazing. Most of it has a growth of sagebrush or cheatgrass. This soil is suited to dry-farmed grain and to irrigated small grains, hay, and pasture. Water for irrigation could be pumped from the river. Yields should be fairly high.

Odin sandy loam

This soil occurs in the irrigated region of Deschutes County in level, slightly concave, or small basinlike areas. Drainage is imperfect to poor.

Typical profile:

0 to 11 inches, light brownish-gray to light-gray noncalcareous sandy loam or light gritty loam; single-grain structure; friable or very friable, when moist, very dark grayish brown or dark gray; about neutral in reaction; contains much pumice sand.

11 to 37 inches, light brownish-gray sandy clay loam or clay loam, grading to light gray or pale brown; noncalcareous; firm to friable; subangular blocky structure; contains some firm rounded nodules; contains considerable pumice sand; neutral or mildly alkaline; moderate fine pores; in many places, a few very dark gray stains of iron and manganese on aggregates, and a very few, small, very dark gray, hard concretions of iron and manganese; when wet, dark grayish brown.

37 inches+, light brownish-gray to pale-brown weakly to strongly cemented sandstone over stratified sandstone and sandy material; mildly to moderately alkaline.

In places a few small mottles of light gray, light yellowish brown, or pale brown are in the surface soil and subsoil. In some areas the lower subsoil or the cemented sandstone substratum is slightly calcareous. A few pebbles or cobblestones of basalt or red rhyolite may occur in the soil or underlying material. Soluble salts accumulate slightly in a few places.

Odin sandy loam, 0 to 3 percent slopes (Oc).—This soil is similar to Odin clay loam, 0 to 3 percent slopes, except for its coarser texture.

Use and management (subgroup 1L).—Almost three-fourths of this soil is under irrigation and is used for crops or pasture. About 15 acres are intermittent ponds. A small acreage is in sagebrush, juniper, and grass. The main crops are oats, barley, wheat, alsike clover, vetch, and potatoes.

Because drainage is inadequate, this soil is not well suited to alfalfa. The better drained areas are fairly well suited to potatoes. This soil is very well suited to grass-legume pasture. Many areas cannot feasibly be drained by ditches, and require wells that are drilled to a pervious layer.

Pits and dumps

Pits and dumps (GP).—Open excavations and piles of rock or soil material that have been removed from the excavations are mapped as pits and dumps. They are shown on the soil map by the conventional sign for gravel pits or by the symbol GP. Many of the pits are sources of gravel used as concrete aggregate or for road surfacing. The soil material that overlaid the gravel is generally near the pits. Along the highways are borrow pits from which the soil and, in places, some of the underlying material has been removed to be used as fill. Most of the borrow pits are shallow. Other pits are sources of rock, pumice for building blocks, or volcanic cinders.

Pits and dumps have no agricultural value for growing plants. A few may hold water and serve as reservoirs for watering livestock.

Redmond clay loam

All of the Redmond clay loam in the Area occurs in the northern part of Deschutes County. This soil is somewhat similar to Odin clay loam, but drainage is moderately good. It has a surface soil of light clay loam or sandy clay loam and a subsoil of clay loam or sandy clay loam. In places the surface soil is a heavy loam.

One phase of this soil is mapped.

Redmond clay loam, 0 to 3 percent slopes (Ra).—This soil is similar to Redmond sandy loam, 0 to 3 percent slopes, except that it is finer in texture and drainage is slower. Runoff is slow and the erosion hazard negligible

Use and management (subgroup 1J).—Almost all of this soil is used for irrigated crops and pasture. Because of its fine texture, it is not well suited to potatoes. Inadequately drained areas are not well suited to alfalfa. Areas that are moderately well drained are suited to oats, wheat, clover, and vetch, and to grass-legume pasture.

Redmond loam

Redmond loam occurs in Deschutes County and in the southern part of Jefferson County. It is similar to Redmond sandy loam except that its surface soil is loam and its subsoil may be slightly finer textured clay loam.

One phase of this soil is mapped.

Redmond loam, 0 to 3 percent slopes (Rb).—This soil is more fertile than Redmond sandy loam, 0 to 3 percent slopes, and higher in water-holding capacity.

Use and management (subgroup 1A).—Most of this soil is used for irrigated crops and pasture. A few areas are in natural vegetation. In use and management this soil is similar to Redmond sandy loam, 0 to 3 percent slopes, but yields are slightly higher.

Redmond sandy loam

Redmond sandy loam occurs extensively in the northern part of Deschutes County; a few tracts are in Jefferson County. It occurs on nearly level or gently sloping plains, generally between ridges of Scabland. The natural vegetation consists of big sagebrush, juniper, rabbitbrush, bunchgrass, annual grasses, and associated herbs.

The upper 20 inches or more of this soil was developed mainly from pumice, in some places mixed with waterlaid material weathered from basalt, rhyolite, andesite, and sandstone. In many places, the lower part of this soil has been affected by material weathered from basalt or partly consolidated pumiceous or tuffaceous sandstone.

This soil is associated with Deschutes sandy loam and Odin sandy loam; in characteristics it is intermediate between these two soils. It is moderately well drained to imperfectly drained; most areas, especially the irrigated areas, are moderately well drained. It has a finer textured, more compact subsoil than Deschutes sandy loam, and is somewhat less well drained.

Representative profile:

0 to 8 inches, light brownish-gray to grayish-brown noncalcareous soft sandy loam grading to pale brown; contains much very pale brown and light yellowish-brown pumice sand; when moist, very dark grayish brown and very friable; about neutral in reaction.

8 to 14 inches, pale-brown to light brownish-gray or light yellowish-brown noncalcareous heavy sandy loam or light loam; slightly hard; weak subangular blocky structure; when moist, dark grayish brown and very friable or friable; contains much very pale brown and light yellowish-brown pumice sand; neutral to mildly alkaline.

14 to 27 inches, pale-brown or light yellowish-brown heavy loam or light clay loam grading to light brownish gray; hard; subangular blocky structure; noncalcareous; when moist, dark grayish brown to dark brown or olive brown and firm; contains much pumice sand; mildly or moderately alkaline.

27 to 34 inches, very pale brown slightly calcareous hard sandy loam; grading to light yellowish brown, pale brown, or light brownish gray; generally weakly or very weakly cemented; in places contains very hard lumps or nodules; contains some pumice.

34 inches +, basalt bedrock or, in places, partly consolidated sandstone or agglomerate.

This soil commonly contains a few small pebbles or fragments of basalt. In places the lower subsoil contains a small to moderate number of angular fragments of basalt as large as 10 inches in diameter. In places a layer in the lower subsoil is weakly cemented; the top of this layer is covered with a very dense, pale-brown or pinkish-gray film about 1/20-inch thick. This film is cemented by lime and silica and is impenetrable to roots. This soil is low in organic matter and nitrogen.

Drainage is somewhat rapid through the upper part of this soil, moderate through the subsoil, and very slow through the underlying material. This soil is normally nonsaline and nonalkali, but a few spots are somewhat saline.

To show variations in slope and depth, two phases of this soil are mapped.

Redmond sandy loam, 0 to 3 percent slopes (Rc).—This soil lies between ridges of Scabland in nearly level and level areas and in shallow depressions. Many tracts occur in the lower parts of upland plains in association with the higher Deschutes sandy loam. Runoff is slow and the erosion hazard negligible or slight. In some depressions, excessive irrigation and runoff from higher areas may cause waterlogging of the subsoil or a perched water table. This soil is moderate to somewhat high in water-holding capacity. It is very easy to irrigate. The workability is very good. This soil is generally 2½ to 3 feet in depth to basalt bedrock or a cemented layer that is impenetrable to roots. In many places this depth is 4 or 5 feet.

Use and management (subgroup 1A).—A very large part of this soil is irrigated for crops and pasture (fig. 5). The common crops of the region are grown. In use suitability and management needs, this soil is similar to Deschutes sandy loam, 0 to 3 percent slopes, but it is better suited to oats, wheat, barley, hay crops, and pasture. Inadequately drained tracts are not very well suited to alfalfa.

In inadequately drained areas, it may be feasible to improve the drainage by digging ditches or drilling wells to the pervious layer. Irrigation should be carefully controlled so that no excess water will be applied.

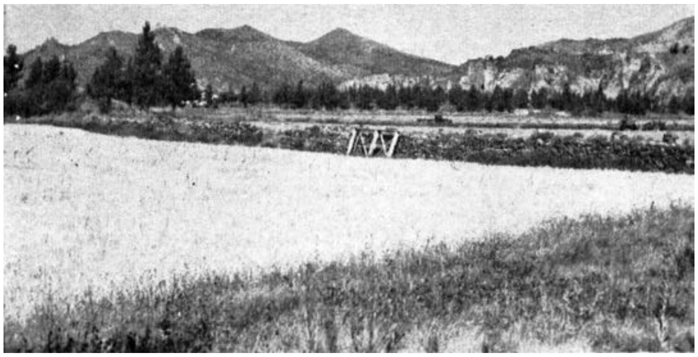

Figure 5.—Barley and alfalfa growing on Redmond sandy loam, 0 to 3 percent slopes. The alfalfa is beyond the stone fence. The grass and weeds in the foreground and the junipers to the left are on Scabland.

Redmond sandy loam, 3 to 7 percent slopes (Rd).—Most of this soil occurs in Deschutes County; a few tracts lie northeast of Madras. This soil is gently sloping or undulating. Runoff is slightly more rapid than it is on Redmond sandy loam, 0 to 3 percent slopes, and irrigation is more difficult. The erosion hazard under irrigation is moderate.

Included with this soil are about 28 acres that have a loam surface soil. Also included are about 24 acres that have slopes of slightly more than 7 percent and 19 acres that are moderately eroded.

Use and management (subgroup 1D).—The acreage of this soil in Deschutes County is irrigated for crops and pasture; that in Jefferson County is used for dry-farmed grain. Some of the areas in Jefferson County may be irrigated under the Deschutes Irrigation Project. In use suitability and management needs this soil is similar to Deschutes sandy loam, 3 to 7 percent slopes, but it is higher in water-holding capacity and fertility.

Redmond sandy loam, deep, 0 to 3 percent slopes (Re).—This soil occurs in the northern part of Deschutes County and in several tracts in Jefferson County east of Madras. It is like Redmond sandy loam, 0 to 3 percent slopes, except that it is deeper to bedrock or a cemented layer and is a little less likely to be waterlogged.

Use and management (subgroup 1A).—This soil is used for dry-farmed grain. It may be irrigated under the Deschutes Irrigation Project. In use suitability and management needs this soil is similar to Deschutes sandy loam, 0 to 3 percent slopes, but where adequately drained it is better suited to alfalfa.

Riverwash

Most areas of Riverwash lie along the Deschutes and Crooked Rivers. One area is along Willow Creek. Most Riverwash is nearly barren, but in places a little sagebrush and grass grow, and in other areas there are a few trees.

Riverwash (Rk) consists of loose sand, gravel, cobblestones, and stones that occur in or near stream beds, overflow channels, or on islands or bars. It normally contains a little silt and clay. It may be covered by floods that shift the material. Hardly anything will grow on it. This mapping unit is in management group 6.

Rough broken land

Rough broken land consists of moderately steep, hilly, and steep land that is broken by many intermittent drainage channels. This miscellaneous land type is not excessively stony. It can be tilled enough to prepare for seeding grass. The natural vegetation consists of big sagebrush, rabbitbrush, bunchgrass, scattered junipers, annual grasses, and associated herbs.

Rough broken land, Era and Deschutes soil materials, 12 to 50 percent slopes (Ro).—This mapping unit consists of several undifferentiated soils. Some areas that are covered with pumiceous materials resemble Deschutes soils. In other areas the soils are less pumiceous and were derived mainly from weathered partly consolidated sandstone, agglomerate, and other rocks of the Dalles formation. In many areas the soils are somewhat similar to Era soils; in other places they are similar to Agency, Madras, Lamonta, and other soils. In a few places the parent material was derived mainly from weathered basalt, and the soils resemble a shallow Gem soil. The soils are generally shallow and low in water-holding capacity.

About 80 percent of this mapping unit has slopes that range from 20 to 35 percent. Runoff varies from place to place but normally ranges from moderate to somewhat high. Many areas are moderately eroded. Natural geologic erosion is active in much of the area.

Use and management (group 5).—This mapping unit is not suitable for irrigation. Its principal use is spring and fall grazing. The carrying capacity is low but can be increased by improved range management.

Rough stony land

Rough stony land consists of moderately steep, hilly, steep, very steep, and precipitous land that has enough stones, boulders, and rock outcrops to prevent ordinary tillage. The natural vegetation consists mainly of big sagebrush, bunchgrasses, rabbitbrush, annual grasses, scattered junipers, and associated herbs. Junipers are larger and more numerous in the southern part of the Area. Ponderosa pine and bitterbrush also grow in small areas in the extreme southern and southwestern parts of the Area.

Rough stony land, Agency and Deschutes soil materials, 12 to 60 percent slopes (Rs).—The soils and soil materials included in this mapping unit are not differentiated. The soils are commonly shallow. Many areas are 90 percent stones and rock outcrops. Such areas include many rimrocks and vertical canyon walls of basalt or other lava (fig. 6). These areas are shown on the map by rock-cliff symbols. They are impassable by livestock.

***Figure 6.*—Rough stony land, Agency and Deschutes soil materials, 12 to 60 percent slopes, in lower Deschutes River valley near the northwest corner of the Area. The rimrock—a basaltic lava flow—terminates in the nearly level Agency Plains higher above it and protects the plains against dissection. The river, however, has cut through the lava strata of the Dalles and the John Day formations.**

Several kinds of soil are intricately associated in this mapping unit. In many areas the soils were derived from weathered sandstone or agglomerate and basalt and somewhat resemble a stony or shallow Agency soil. In other places the soils resemble a stony or shallow Era soil. To the southward many of the areas are mantled with pumiceous sandy materials, and the soils are similar to Deschutes soils.

About 62 percent of this mapping unit has slopes of more than 35 percent, and 30 percent has slopes of 20 to 25 percent. Runoff is moderate to high. Many areas have been moderately eroded. Natural geologic erosion is active in most places.

Use and management (group 6).—This land type is used mainly for spring and fall grazing. It is not suited to irrigation or dry farming. It is similar to Rough broken land in management needs, but in most places plowing or disking to prepare for seeding grass is not feasible. The carrying capacity is about the same as or a little lower than that of Rough broken land.

Scabland

Scabland occurs mostly in Deschutes County. It consists of level and undulating upland plains where blisterlike outcrops of basalt occur. Many ridges, low knolls, swales, and pockets were formed when the lava cooled and hardened. Later a mantle of pumice particles settled from the air on these uneven surfaces. Water and wind moved much of the pumice from the higher, more exposed places to the lower areas where Deschutes, Redmond, and Odin soils developed. In many places on the upland plain, basalt or other lava rock now crops out or is within a few inches of the surface. In cavities and small pockets in the lava the covering of pumice particles or other soil material is deeper. Scabland consists of areas in which the bedrock predominates; areas in which stony shallow soil and soil-forming material predominate are recognized as Rough stony land.

The natural vegetation of Scabland consists mainly of big sagebrush, open stands of juniper, rabbitbrush, bunchgrass, annual grasses, and associated herbs. In some areas in the extreme southern and southwestern part ponderosa pine and bitterbrush grow.

Because some nearly level areas of Scabland are suitable for irrigated pastures, two phases are mapped.

Scabland, 0 to 3 percent slopes (Sa).—Most of this mapping unit occurs in Deschutes County. It is in management group 6. Most of it is used for range grazing, mainly in spring and fall. The carrying capacity is low. Management needs for range are similar to those of Rough stony land. A few tracts where the soil is deepest are irrigated for grass-legume pasture. The grazing capacity of the irrigated tracts is higher than that of the native range.

Scabland, 3 to 12 percent slopes (Sb).—Extensive tracts of this miscellaneous land type occur in the southeastern part of the Area. It is associated with Deschutes and Redmond soils in swales and shallow basins. About 84 percent is gently sloping or undulating; the rest is moderately sloping or rolling.

This mapping unit is in management group 6. In use suitability and management needs it is similar to Scabland, 0 to 3 percent slopes, but it is less suitable for irrigated pasture.

Volcanic ash

Volcanic ash consists of inextensive areas of relatively unmodified deposits of white or light-gray fine volcanic ejecta, mixed with some soil material that washed from adjoining higher land. The sparse vegetation consists mostly of rabbitbrush.

Volcanic ash, 0 to 3 percent slopes (Vo).—This miscellaneous land type occupies nearly level, low, concave slopes in draws, basinlike areas, or the beds of former ponds. It consists of glassy or pumiceous loose sand, loamy sand, or finer material that shows little evidence of soil development. Below a depth of 4 feet the material is pale-brown fine sandy loam that contains weakly cemented nodules of soil material. Diatomaceous material possibly is included.

This land type is in management subgroup 1B. It is poor for grazing.

Use and Management of Soils

The soils and miscellaneous land types of the Area are placed in management groups and subgroups on the basis of characteristics that determine their similarity in use suitability and management needs. For each subgroup suitable uses are given and, if applicable, suitable rotations, suggested fertilization, irrigation methods, and other management. The suggested fertilization is given in general terms only. Advice on specific amounts of fertilizer can be obtained from the county agricultural agent, from qualified advisers in the Agricultural Experiment Station and the Soil Conservation Service, and from others who may have adequate knowledge of soil conditions in the Area. Soil tests help to show how much fertilizer is needed. The suitable rotations, unless otherwise specified, are for irrigated soils.

Management Group 1

Management group 1 consists of soils of the uplands and terraces. These soils were derived mainly from pumice. They are placed in 12 subgroups, generally on the basis of drainage, texture, depth, and slope.

Management subgroup 1A

Subgroup 1A consists of the following moderately deep or deep soils that range from moderately well drained to somewhat excessively drained:

Deschutes coarse sandy loam, over sandy material, 0 to 3 percent slopes.
Deschutes loam, stony, 0 to 3 percent slopes.
Deschutes sandy loam, 0 to 3 percent slopes.
Deschutes sandy loam, deep, 0 to 3 percent slopes.
Deschutes sandy loam, deep over cinders, 0 to 3 percent slopes.
Deschutes sandy loam, over cinders, 0 to 3 percent slopes.
Deschutes sandy loam, over semicemented sandy material, 0 to 3 percent slopes.
Deschutes sandy loam, stony, 0 to 3 percent slopes.
Deschutes sandy loam, stony, over semicemented sandy material, 0 to 3 percent slopes.
Laidlaw sandy loam, 0 to 3 percent slopes.
Redmond loam, 0 to 3 percent slopes.
Redmond sandy loam, 0 to 3 percent slopes.
Redmond sandy loam, deep, 0 to 3 percent slopes.

Suitable uses

Irrigated crops: Potatoes, alfalfa, oats, barley, wheat, and peas; alsike clover, Ladino clover, and red clover for seed or hay; vetch for seed.

Irrigated pasture: Grass-legume mixture.

Suitable rotations

Grain; alfalfa for 5 years; potatoes for 2 years; grain in which red clover or alsike clover is seeded; then a crop of clover seed or clover hay.

Oats or barley with alsike clover or Ladino clover seeded in the stubble in August; 2 years of clover for seed; potatoes for 1 year.

Oats, barley, or wheat; hairy vetch or peas; potatoes.

Barley or oats followed by vetch.

Suggested fertilization

Fertilize alfalfa and clover grown for seed with gypsum and phosphoric acid (P_2O_5).

Fertilize potatoes that follow alfalfa or clover with phosphoric acid, potash (K_2O), and borax. Use additional nitrogen if potatoes are grown for a second year.

Fertilize vetch with phosphoric acid.

Fertilize peas with nitrogen, in addition to gypsum and phosphoric acid.

Except when it follows potatoes, alfalfa, or clover, fertilize grain with nitrogen and phosphoric acid.

Fertilize pastures with gypsum, phosphoric acid, and, where needed, nitrogen.

Irrigation methods

Irrigate row crops by furrows. Irrigate grains, hay, and pasture in strip. borders.

Other management

Apply manure to potatoes, other row crops, and grains; use all crop residues; remove stones from stony soils.

Divide pasture into three or four units and rotate grazing; do not graze new stands until they are well established; clip pasture to control weeds; harrow pasture to scatter droppings. Plow pasture and use for potatoes or other crops, and reseed to pasture when necessary.

Management subgroup 1B

Subgroup 1B consists of the following moderately deep, somewhat excessively drained soils:

Deschutes loamy coarse sand, over gravelly material, 0 to 3 percent slopes.
Deschutes loamy sand, 0 to 3 percent slopes.
Deschutes loamy sand, eroded, 0 to 3 percent slopes.
Deschutes loamy sand, over cinders, 0 to 3 percent slopes.
Deschutes loamy sand, over cobbly material, 0 to 3 percent slopes.
Deschutes loamy sand, over gravelly material, 0 to 3 percent slopes.
Deschutes loamy sand, over semicemented sandy material, 0 to 3 percent slopes.
Volcanic ash, 0 to 3 percent slopes.

Suitable uses

Irrigated crops: Potatoes, alfalfa, oats, barley, and wheat; alsike clover, Ladino clover, and red clover for seed or hay; vetch for seed; peas.

Irrigated pasture: Grass-legume mixture.

Suitable rotations

Grain; alfalfa for 5 or more years; potatoes for 1 year; grain in which red clover or alsike clover is seeded; then 1 year of clover for seed or hay.

Oats or barley, with alsike clover or Ladino clover seeded in the stubble in August; 2 years of clover for seed; 1 year of potatoes.

Oats, barley, or wheat; hairy vetch or peas; then potatoes.

Barley or oats, followed by vetch.

Suggested fertilization

Fertilize alfalfa and clover for seed with gypsum and phosphoric acid (P_2O_5).

Fertilize potatoes following alfalfa or clover with nitrogen, phosphoric acid, potash (K_2O), and borax. Increase nitrogen for potatoes grown the second year.

Fertilize vetch with phosphoric acid.

Fertilize peas with nitrogen in addition to gypsum and phosphoric acid.

Except when it follows potatoes, alfalfa, or clover, fertilize grain with nitrogen and phosphoric acid.

Fertilize pastures with gypsum and phosphoric acid; where needed, apply nitrogen.

Irrigation methods

Irrigate row crops by furrows. Irrigate grains, hay, and pasture in strip borders. Apply water in smaller quantities, from larger heads, and more often than for subgroup 1A.

Other management

For crops, apply manure and turn under green manure and crop residues.

Divide pasture into three or four units and rotate grazing; defer grazing of new stands until they are well established; clip to control weeds; harrow to scatter droppings. Plow pasture and use for potatoes or other crops, and reseed to pasture when necessary.

Management subgroup 1C

Subgroup 1C consists of the following well-drained soils:

Deschutes sandy loam, shallow, 0 to 3 percent slopes.
Deschutes sandy loam, shallow over cinders, 0 to 3 percent slopes.

Suitable uses

Irrigated crops: Potatoes, Ladino clover for seed or hay, oats, barley, wheat, vetch for seed, and peas.

Irrigated pasture: Grass-legume mixture.

Suitable rotations

Grain, followed by vetch or peas, then potatoes.

Oats or barley, followed by vetch.

Suggested fertilization

Fertilize alfalfa and clover for seed with gypsum and phosphoric acid (P_2O_5).

Fertilize potatoes that follow alfalfa or clover with nitrogen, phosphoric acid, potash (K_2O), and borax. Apply more nitrogen if potatoes are grown a second year.

Fertilize vetch with phosphoric acid.

Fertilize peas with nitrogen, in addition to gypsum and phosphoric acid.

Fertilize grain, if it does not follow potatoes, alfalfa, or clover, with nitrogen and phosphoric acid.

Fertilize pastures with nitrogen.

Irrigation methods

Irrigate row crops by furrows. Irrigate grains, hay, and pasture in strip borders. The soils of this subgroup also can be irrigated by corrugations.

Other management

For crops, apply manure and turn under green manure and crop residues.

Divide pasture into three or four units and rotate grazing; defer grazing of new stands until they are well established; clip to control weeds; harrow to scatter droppings.

Management subgroup 1D

Subgroup 1D consists of the following well drained or moderately well drained soils that are moderately deep or deep:

Deschutes sandy loam, 3 to 7 percent slopes.
Deschutes sandy loam, deep, 3 to 7 percent slopes.
Deschutes sandy loam, over cinders, 3 to 7 percent slopes.
Deschutes sandy loam, over cinders, eroded, 3 to 7 percent slopes.
Deschutes sandy loam, over semicemented sandy material, 3 to 7 percent slopes.
Deschutes sandy loam, stony, 3 to 7 percent slopes.
Deschutes sandy loam, stony, over cinders, 3 to 7 percent slopes.
Deschutes sandy loam, stony, over semicemented sandy material, 3 to 7 percent slopes.
Laidlaw sandy loam, 3 to 7 percent slopes.
Redmond sandy loam, 3 to 7 percent slopes.

Suitable uses

Irrigated crops: Potatoes, alfalfa, oats, barley, and wheat; alsike clover, Ladino clover, or red clover for seed or hay; vetch for seed; peas.

Irrigated pasture: Grass-legume mixture.

Suitable rotations

Grain; alfalfa for 5 years; potatoes for 1 year; grain seeded to red clover or alsike clover; then 1 year of clover for seed or hay.

Oats or barley with alsike clover or Ladino clover seeded in stubble in August; 2 years of clover for seed; then potatoes.

Oats, barley, or wheat; 1 year of hairy vetch or peas; then potatoes.

Barley or oats, followed by 1 year of vetch.

Suggested fertilization

Fertilize alfalfa and clover for seed with gypsum and phosphoric acid (P_2O_5).

Fertilize potatoes that follow alfalfa or clover with nitrogen, phosphoric acid, potash (K_2O), and borax. Apply additional nitrogen if potatoes are grown a second year.

Fertilize vetch with phosphoric acid.

Fertilize peas with nitrogen, in addition to gypsum and phosphoric acid.

Except when it follows potatoes, alfalfa, or clover, fertilize grain with nitrogen and phosphoric acid.

Fertilize pastures with nitrogen.

Irrigation methods

Irrigate row crops by furrows. Irrigate grains, hay, and pasture by corrugations or by flooding from contour laterals.

Other management

For crops, apply manure and turn under green manure and crop residues.

Divide pasture into three or four units and rotate grazing; defer grazing of new stands until they are well established; clip to control weeds; harrow to scatter droppings. Plow pasture and use for potatoes or other row crops, and reseed when needed.

Management subgroup 1E

Subgroup 1E consists of the following somewhat excessively drained soils that are moderately deep:

Deschutes loamy coarse sand, over gravelly material, 3 to 7 percent slopes.
Deschutes loamy sand, 3 to 7 percent slopes.
Deschutes loamy sand, over cinders, 3 to 7 percent slopes.
Deschutes loamy sand, over cinders, eroded, 3 to 7 percent slopes.
Deschutes loamy sand, over gravelly material, 3 to 7 percent slopes.
Deschutes loamy sand, over semicemented sandy material, 3 to 7 percent slopes.

Suitable uses

Irrigated crops: Potatoes, alfalfa, oats, barley, and wheat; alsike, Ladino, and red clovers for seed or hay; vetch for seed; peas.

Irrigated pasture: Grass-legume mixture; for example, orchardgrass, alta fescue, smooth bromegrass, and Ladino clover or alsike clover, or both.

Suitable rotations

Grain; alfalfa for 5 years; potatoes for 1 year; grain seeded to red clover or alsike clover for 1 year; clover for seed or hay for 1 year.

Oats or barley, with clover seeded in stubble in August; 2 years of alsike clover or Ladino clover for seed; potatoes.

Oats, barley, or wheat; hairy vetch or peas; potatoes.

Barley or oats, followed by vetch.

Suggested fertilization

Fertilize alfalfa and clover for seed with gypsum and phosphoric acid (P_2O_5).

Fertilize potatoes that follow alfalfa or clover with nitrogen, phosphoric acid, potash (K_2O), and borax. Apply more nitrogen if potatoes are grown a second year.

Fertilize vetch with phosphoric acid.

Fertilize peas with nitrogen, in addition to gypsum and phosphoric acid.

Except when it follows potatoes, alfalfa, or clover, fertilize grain with nitrogen and phosphoric acid.

Fertilize pastures with gypsum, phosphoric acid, and, where needed, nitrogen.

Irrigation methods

Irrigate row crops by furrows. Irrigate grains, hay, and pasture by corrugations or by flooding from contour laterals. Control irrigation water carefully to prevent erosion.

Other management

For crops, apply manure and turn under green manure and crop residues.

Divide pasture into three or four units and rotate grazing; defer grazing of new stands until they are well established; clip to control weeds; harrow to scatter droppings. Plow pasture and use for potatoes or other crops, and reseed when needed.

Management subgroup 1F

Subgroup 1F consists of the following shallow, well-drained sandy loams:

Deschutes sandy loam, shallow, 3 to 7 percent slopes.
Deschutes sandy loam, shallow over cinders, eroded, 3 to 7 percent slopes.

Suitable uses

Irrigated crops: Potatoes, Ladino clover for seed and hay, oats, barley, wheat, vetch for seed, and peas.

Irrigated pasture: Grass-legume mixture.

Suitable rotations

Grain; vetch or peas; potatoes.

Oats or barley, followed by vetch.

Suggested fertilization

Fertilize alfalfa and clover for seed with gypsum and phosphoric acid (P_2O_5).

Fertilize potatoes that follow alfalfa or clover with nitrogen, phosphoric acid, potash (K_2O), and borax. Apply more nitrogen if potatoes are grown a second year.

Fertilize vetch with nitrogen, in addition to gypsum and phosphoric acid.

Except when it follows potatoes, alfalfa, or clover, fertilize grain with nitrogen and phosphoric acid.

Fertilize pastures with nitrogen.

Irrigation methods

Irrigate row crops by furrows. Irrigate grains, hay, and pasture by corrugations or by flooding from contour laterals.

Other management

For crops, apply manure and turn under green manure and crop residues.

Divide pasture into three or four units and rotate grazing; defer grazing of new stands until they are well established; clip to control weeds; harrow to scatter droppings. Plow pasture and use for potatoes or other row crops, and reseed when needed.

Management subgroup 1G

Subgroup 1G consists of the following well-drained sandy loams:

Deschutes sandy loam, 7 to 12 percent slopes.
Deschutes sandy loam, eroded, 7 to 12 percent slopes.
Deschutes sandy loam, over semicemented sandy material, 7 to 12 percent slopes.
Deschutes sandy loam, stony, 7 to 12 percent slopes.
Deschutes sandy loam, stony, over semicemented sandy material, 7 to 12 percent slopes.
Laidlaw sandy loam, 7 to 12 percent slopes.
Laidlaw sandy loam, eroded, 7 to 12 percent slopes.

Suitable uses

Irrigated crops: Alfalfa, alsike clover, Ladino clover, red clover, oats, barley, and wheat.

Irrigated pasture: Grass-legume mixture; for example, orchardgrass, alta fescue, smooth bromegrass, and Ladino clover or alsike clover, or both.

Range grazing.

Suitable rotations

Grain, followed by 5 or 6 years of alfalfa.

Grain, followed by 2 or 3 years of clover.

Suggested fertilization

Fertilize alfalfa and clover for seed with gypsum and phosphoric acid (P_2O_5).

Except when it follows alfalfa or clover, fertilize grain with nitrogen and phosphoric acid.

Fertilize pastures with phosphoric acid and, where needed, nitrogen.

Irrigation methods

Irrigate by corrugations or by flooding from contour laterals.

Other management

Apply manure to grains; use all crop residues; remove stones from stony soils.

Divide pasture into three or four units and rotate grazing; do not graze new stands until they are well established; clip pasture to control weeds; harrow to scatter droppings. Plow, sow to grain, and reseed when necessary.

Regulate stocking of range. Defer grazing until new growth is 3 to 5 inches high; do not graze too short late in fall; graze tracts in rotation; provide adequate winter feed. Keep stock distributed by fences or by the location of water and salt.

Management subgroup 1H

Subgroup 1H consists of the following somewhat excessively drained soils:

Deschutes loamy sand, 7 to 12 percent slopes.
Deschutes loamy sand, over semicemented sandy material, 7 to 12 percent slopes.

Suitable uses

Irrigated crops: Alfalfa, alsike clover, Ladino clover, red clover, oats, barley, and wheat.

Irrigated pasture: Grass-legume mixture.

Range grazing.

Suitable rotations

Grain; alfalfa for 5 or 6 years.

Grain; clover for 2 or 3 years.

Suggested fertilization

Fertilize alfalfa and clover for seed with gypsum and phosphoric acid (P_2O_5).

Except when it follows alfalfa or clover, fertilize grain with nitrogen and phosphoric acid.

Fertilize pastures with phosphoric acid and, where needed, nitrogen.

Irrigation methods

Irrigate by corrugations or by flooding from contour laterals.

Other management

Apply manure to grains; use all crop residues; remove stones from stony soils.

Divide pasture into three or four units and rotate grazing; do not graze new stands until they are well established; clip pasture to control weeds; harrow to scatter droppings. Plow, sow to grain, and reseed when necessary; use straw mulch when reseeding.

Regulate stocking of range; defer grazing until new growth is 3 to 5 inches high; do not graze too short late in fall; graze tracts in rotation; provide adequate winter feed. Keep stock distributed by fencing and by location of water and salt.

Management subgroup 1I

Subgroup 1I consists of the following well-drained sandy loams:

Deschutes sandy loam, 12 to 20 percent slopes.
Deschutes sandy loam, over semicemented sandy material, eroded, 12 to 20 percent slopes.
Laidlaw sandy loam, eroded, 12 to 20 percent slopes.

Suitable use

The soils of this subgroup are suitable only for range grazing.

Management

Regulate stocking of range; defer grazing until new growth is 3 to 5 inches high; do not graze too short late in fall; graze tracts in rotation; provide adequate winter feed. Keep stock distributed by fencing and by location of water and salt. Seed cleared or burned areas to crested wheatgrass mixed with a little bulbous bluegrass and perhaps some beardless wheatgrass and bluebunch wheatgrass.

Management subgroup 1J

Redmond clay loam, 0 to 3 percent slopes, is the only soil in subgroup 1J. It is moderately well drained.

Suitable uses

Irrigated crops: Alfalfa, oats, barley, and wheat; alsike, Ladino, and red clovers for seed or hay; vetch for seed; peas.

Irrigated pasture: Grass-legume mixture.

Suitable rotations

Grain; alfalfa for 5 years; grain seeded to red clover or alsike clover; clover for seed or hay.

Oats or barley with alsike clover or Ladino clover seeded in stubble in August; 2 years of clover for seed; potatoes for 1 year.

Oats, barley, or wheat; hairy vetch or peas; then potatoes.

Barley or oats, followed by vetch.

Suggested fertilization

Fertilize vetch with phosphoric acid (P_2O_5).

Fertilize peas with nitrogen, gypsum, and phosphoric acid.

Except where it follows alfalfa or clover, fertilize grain with nitrogen and phosphoric acid.

Fertilize pasture with gypsum, phosphoric acid, and, where needed, nitrogen.

Irrigation methods

Irrigate by strip borders.

Other management

Apply manure to grains; use all crop residues.

Divide pasture into three or four units and rotate grazing; do not graze new stands until they are well established; clip pasture to control weeds; harrow pasture to scatter droppings. Plow pasture and use for crops, and reseed when needed.

Management subgroup 1K

Subgroup 1K consists of the following imperfectly drained and poorly drained soils:

Odin clay loam, 0 to 3 percent slopes.
Odin clay loam, 3 to 7 percent slopes.

Suitable uses

Irrigated crops: Oats, barley, wheat, Ladino clover, alsike clover, and vetch.

Irrigated pasture: Grass-legume mixture.

Dry-farmed crops: Wheat for grain; rye and barley for hay.

Suitable rotations

For irrigated areas, suitable rotations include the following: Grain, followed by vetch; and grain followed by 2 or 3 years of clover.

For dry-farmed areas, a suitable rotation consists of grain alternating with summer fallow for 10 years, then 5 or 6 years of crested wheatgrass and bulbous bluegrass.

Suggested fertilization

Fertilize alfalfa and clover grown for seed with gypsum and phosphoric acid (P_2O_5).

Fertilize vetch with phosphoric acid.

Fertilize peas with nitrogen, in addition to gypsum and phosphoric acid.

Fertilize pasture with gypsum, phosphoric acid, and, where needed, nitrogen.

Irrigation methods

Irrigate by strip borders. Do not overirrigate.

Other management

Provide artificial drainage by ditches and drainage wells that extend into a pervious layer, or by pumping for irrigation. Flush and flood saline areas.

Fallow dry-farmed areas to conserve moisture. While soil is fallow, cultivate to control weeds. Maintain stubble mulch; spread straw and do not burn it.

Management subgroup 1L

Odin sandy loam, 0 to 3 percent slopes, is the only soil in subgroup 1L. It is imperfectly drained.

Suitable uses

Irrigated crops: Potatoes, oats, barley, wheat, Ladino clover, alsike clover, and vetch.

Irrigated pasture: Grass-legume mixture.

Suitable rotations

Grain, followed by vetch.

Grain, followed by clover for 2 or 3 years.

Grain; vetch; potatoes.

Suggested fertilization

Fertilize alfalfa and clover for seed with gypsum and phosphoric acid (P_2O_5).

Fertilize potatoes following alfalfa or clover with nitrogen, phosphoric acid, potash (K_2O), and borax. Increase nitrogen for potatoes grown a second year.

Fertilize vetch with phosphoric acid.

Except when it follows potatoes, alfalfa, or clover, fertilize grain with nitrogen and phosphoric acid.

Fertilize pasture with gypsum, phosphoric acid, and, where needed, nitrogen.

Irrigation methods

Irrigate potatoes by furrow runs. Irrigate grains, hay, and pasture with strip borders. Do not overirrigate.

Other management

Provide artificial drainage by ditches, by drainage wells that extend into a pervious layer, or by pumping for irrigation. Flush and flood saline areas. Fallow dry-farmed areas to conserve moisture. While soil is fallow, cultivate to control weeds. Maintain stubble mulch; spread straw and do not burn it.

Management Group 2

Management group 2 consists of soils of the uplands that were derived from weathered sandstones, agglomerates, and mixed materials. They are placed in 9 subgroups, generally on the basis of texture of the subsoil, depth, and slope.

Management subgroup 2A

Subgroup 2A consists of the following soils that have sandy loam, loam, or clay loam subsoils.

Agency gravelly loam, 0 to 3 percent slopes.
Agency loam, 0 to 3 percent slopes.
Agency loam, eroded, 0 to 3 percent slopes.
Agency sandy loam, 0 to 3 percent slopes.
Agency sandy loam, eroded, 0 to 3 percent slopes.
Era sandy loam, 0 to 3 percent slopes.
Era sandy loam, eroded, 0 to 3 percent slopes.
Madras loam, 0 to 3 percent slopes.
Madras loam, eroded, 0 to 3 percent slopes.
Madras loam, over sandstone, 0 to 3 percent slopes.
Madras loam, over sandstone, eroded, 0 to 3 percent slopes.
Madras sandy loam, 0 to 3 percent slopes.
Madras sandy loam, deep over sandstone, 0 to 3 percent slopes.
Madras sandy loam, eroded, 0 to 3 percent slopes.
Madras sandy loam, over sandstone, 0 to 3 percent slopes.
Madras sandy loam, over sandstone, eroded, 0 to 3 percent slopes.

Suitable uses

Irrigated crops: Potatoes, alfalfa, oats, barley, and wheat; alsike clover, Ladino clover, and red clover for seed or hay; vetch for seed; peas.

Irrigated pasture: Grass-legume mixture.

Dry-farmed crops: Wheat for grain; rye and barley for hay.

Suitable rotations

The following rotations are suitable for irrigated areas:

Grain; alfalfa for 5 years; potatoes for 2 years; grain; red clover or alsike clover, seeded in preceding grain crop and harvested for seed and hay.

Oats or barley, with alsike clover or Ladino clover seeded in the stubble in August; 2 years of clover for seed; potatoes.

Oats, barley, or wheat; hairy vetch or peas; potatoes.

Barley or oats, followed by vetch.

A suitable rotation for dry-farmed areas consists of grain alternating with summer fallow for 10 years, then 5 or 6 years of crested wheatgrass and bulbous bluegrass.

Suggested fertilization

Fertilize alfalfa and clover with gypsum.

Fertilize clover grown for seed with phosphoric acid (P_2O_5).

Fertilize potatoes that follow alfalfa or clover with nitrogen, phosphoric acid, and potash (K_2O).

Fertilize grain and peas with ammonium sulfate.

Fertilize pasture with ammonium sulfate.

Irrigation methods

Irrigate row crops on gravelly loams and sandy loams by furrows. Irrigate grains, hay, and pasture on gravelly loams and sandy loams in strip borders. On loam soils irrigation runs can be longer than on the sandy loams.

Other management

Apply manure to potatoes, other row crops, and grains; use all crop residues; remove stones from stony soils.

Divide pasture into three or four units and rotate grazing; do not graze new stands until they are well established; clip pasture to control weeds; harrow pasture to scatter droppings. Plow pasture and use for potatoes or other crops, and reseed when necessary.

Fallow dry-farmed areas to conserve moisture. While the soil is fallow, cultivate to control weeds. Maintain stubble mulch; spread straw and do not burn it.

Management subgroup 2B

Subgroup 2B consists of the following soils that have sandy loam, loam, or clay loam subsoils and slopes of 3 to 7 percent.

Agency gravelly loam, 3 to 7 percent slopes.
Agency gravelly loam, eroded, 3 to 7 percent slopes.
Agency loam, 3 to 7 percent slopes.
Agency loam, eroded, 3 to 7 percent slopes.
Agency sandy loam, 3 to 7 percent slopes.
Agency sandy loam, eroded, 3 to 7 percent slopes.
Era sandy loam, 3 to 7 percent slopes.
Era sandy loam, eroded, 3 to 7 percent slopes.
Madras loam, 3 to 7 percent slopes.
Madras loam, eroded, 3 to 7 percent slopes.
Madras loam, over sandstone, 3 to 7 percent slopes.
Madras loam, over sandstone, eroded, 3 to 7 percent slopes.
Madras loamy sand, over sandstone, 3 to 7 percent slopes.
Madras loamy sand, over sandstone, eroded, 3 to 7 percent slopes.
Madras sandy loam, 3 to 7 percent slopes.
Madras sandy loam, deep over sandstone, 3 to 7 percent slopes.
Madras sandy loam, deep over sandstone, eroded, 3 to 7 percent slopes.
Madras sandy loam, eroded, 3 to 7 percent slopes.
Madras sandy loam, over sandstone, 3 to 7 percent slopes.
Madras sandy loam, over sandstone, eroded, 3 to 7 percent slopes.

Suitable uses

Irrigated crops: Potatoes, oats, barley, and wheat; alsike clover, Ladino clover, and red clover for seed or hay; vetch for seed; peas.

Irrigated pasture: Grass-legume mixture.

Dry-farmed crops: Wheat for grain; rye and barley for hay.

Suitable rotations

The following rotations are suitable for irrigated areas:

Grain; alfalfa for 5 years; potatoes for 2 years; grain; red clover or alsike clover, seeded in the preceding grain crop and harvested for seed or hay.

Oats or barley, with alsike clover or Ladino clover seeded in the stubble in August; 2 years of clover for seed; potatoes.

Oats, barley, or wheat; hairy vetch or peas; potatoes.

Barley or oats, followed by vetch.

A suitable rotation for dry-farmed areas consists of grain alternating with summer fallow for 10 years, and followed by 5 or 6 years of crested wheatgrass and bulbous bluegrass.

Suggested fertilization

Fertilize alfalfa and clover with gypsum.

Fertilize clover grown for seed with phosphoric acid (P_2O_5).

Fertilize potatoes that follow alfalfa or clover with nitrogen, phosphoric acid, and potash (K_2O).

Fertilize grain and peas with ammonium sulfate.

Fertilize irrigated pasture with ammonium sulfate.

Irrigation methods

Irrigate row crops on gravelly loams and sandy loams by furrows. Irrigate grains, hay, and pasture on gravelly loams and sandy loams by corrugations or by flooding from contour laterals. Runs can be somewhat longer on loams than on sandy loams.

Other management

Apply manure to potatoes, other row crops, and grains; use all crop residues; remove stones from stony soils. Divide pasture into three or four units and rotate grazing; do not graze new stands until they are well established; clip pasture to control weeds; harrow pasture to scatter droppings. Plow pasture and use for potatoes or other row crops, and reseed when needed. Fallow dry-farmed areas to conserve moisture. While the soil is fallow, cultivate to control weeds. Maintain stubble mulch; spread straw and do not burn it.

Management subgroup 2C

Subgroup 2C consists of the following soils that have sandy loam, loam, or clay loam subsoils.

Agency gravelly loam, 7 to 12 percent slopes.
Agency gravelly loam, eroded, 7 to 12 percent slopes.
Agency loam, 7 to 12 percent slopes.
Era sandy loam, 7 to 12 percent slopes.
Era sandy loam, eroded, 7 to 12 percent slopes.
Madras loam, 7 to 12 percent slopes.
Madras loam, eroded, 7 to 12 percent slopes.
Madras sandy loam, 7 to 12 percent slopes.
Madras sandy loam, eroded, 7 to 12 percent slopes.
Madras sandy loam, over sandstone, 7 to 12 percent slopes.
Madras sandy loam, over sandstone, eroded, 7 to 12 percent slopes.

Suitable uses

Irrigated crops: Alfalfa, alsike clover, Ladino clover, red clover, oats, barley, or wheat.

Irrigated pasture: Grass-legume mixture.

Dry-farmed crops: Wheat for grain; rye and barley for hay.

Range grazing.

Suitable rotations

For irrigated areas, suitable rotations include the following: Grain, followed by 5 or 6 years of alfalfa; and grain followed by 2 or 3 years of clover.

For dry-farmed areas, a suitable rotation consists of grain alternating with summer fallow for 10 years, then 5 to 6 years of crested wheatgrass and bulbous bluegrass.

Suggested fertilization

Fertilize alfalfa and clover with gypsum.

Fertilize clover grown for seed with phosphoric acid (P_2O_5).

Fertilize grain with ammonium sulfate.

Fertilize irrigated pasture with gypsum and phosphoric acid; where needed, use nitrogen.

Irrigation methods

For crops and pasture, irrigate by corrugations or by flooding from contour laterals.

Other management

Apply manure to grains; use all crop residues; remove stones from stony soils. Divide pasture into three or four units and rotate grazing; do not graze new stands until they are well established; clip pasture to control weeds; harrow pasture to scatter droppings. Plow pasture and reseed when needed.

Fallow dry-farmed areas to conserve moisture. While soil is fallow, cultivate to control weeds. Maintain stubble mulch. Spread straw and do not burn it; plow on the contour where possible.

Regulate stocking of range; defer grazing until new growth is 3 to 5 inches high; do not graze too short late in fall; graze tracts in rotation. Keep stock distributed over the range by fencing or by location of water and salt. Provide adequate winter feed. Seed cleared or burned areas to crested wheatgrass mixed with a little bulbous bluegrass and perhaps some beardless wheatgrass and bluebunch wheatgrass.

Management subgroup 2D

Subgroup 2D consists of the following loams and sandy loams that have sandy loam, loam, or clay subsoils:

Agency loam, 12 to 20 percent slopes.
Era sandy loam, 12 to 20 percent slopes.
Era sandy loam, eroded, 12 to 20 percent slopes.
Madras sandy loam, over sandstone, 12 to 20 percent slopes.
Madras sandy loam, over sandstone, eroded, 12 to 20 percent slopes.

Suitable uses

Dry-farmed crops: Wheat for grain; rye or barley for hay.

Range grazing.

Irrigated pasture: Grass-legume mixture.

Suitable rotation

For dry-farmed areas, a suitable rotation consists of grain alternating with summer fallow for 10 years, then 5 or 6 years of crested wheatgrass and bulbous bluegrass.

Suggested fertilization

Fertilize irrigated pasture with ammonium sulfate.

Irrigation methods

Irrigate pastures by corrugations or by flooding from contour laterals.

Other management

Fallow dry-farmed areas to conserve moisture; while soil is fallow, cultivate to control weeds. Spread straw and do not burn it. Maintain stubble mulch. Plow on contour where possible.

Regulate stocking of range. Defer grazing until new growth is 3 to 5 inches high; do not graze too short in fall; graze tracts in rotation; provide adequate feed in winter. Keep stock distributed by fencing and by location of water and salt. Seed cleared or burned areas to crested wheatgrass mixed with a little bulbous bluegrass, beardless wheatgrass, and bluebunch wheatgrass.

Divide irrigated pasture into three or four units and rotate grazing; do not graze new stands until they are well established; clip pasture to control weeds; harrow pasture to scatter droppings.

Management subgroup 2E

Subgroup 2E consists of the following moderately deep loams and sandy loams that have clay subsoils:

Lamonta loam, 0 to 3 percent slopes.
Lamonta loam, eroded, 0 to 3 percent slopes.
Lamonta sandy clay loam, 0 to 3 percent slopes.
Lamonta sandy clay loam, eroded, 0 to 3 percent slopes.

Suitable uses

Irrigated crops: Alfalfa, oats, barley, wheat, Ladino clover for seed, peas, and vetch.

Dry-farmed crops: Wheat for grain; rye or barley for hay.

Irrigated pasture: Grass-legume mixture.

Suitable rotations

For irrigated areas, suitable rotations include the following: Grain, followed by 2 years of Ladino clover; and grain followed by peas or vetch.

For dry-farmed areas, a suitable rotation consists of grain alternating with summer fallow for 10 years, then 5 or 6 years of crested wheatgrass and bulbous bluegrass.

Suggested fertilization

Fertilize alfalfa and clover with gypsum.

Fertilize clover grown for seed with phosphoric acid (P_2O_5).

Fertilize grain and peas with ammonium sulfate.

Fertilize irrigated pasture with ammonium sulfate.

Irrigation methods

Irrigate crops in strip borders or corrugations. Use a small head of water. Irrigate pasture in strip borders.

Other management

Apply manure to irrigated grains; use all crop residues; keep grading and leveling to a minimum. Fallow dry-farmed areas to conserve moisture; and while soil is fallow, cultivate to control weeds. Maintain stubble mulch; spread straw and do not burn it.

Divide pasture into three or four units and rotate grazing; do not graze new stands until they are well established; clip pasture to control weeds; harrow pasture to scatter droppings. Plow pasture and use for crops, and reseed when necessary.

Management subgroup 2F

Subgroup 2F consists of the following moderately deep loams and sandy clay loams that have a clay subsoil:

Lamonta loam, 3 to 7 percent slopes.
Lamonta loam, eroded, 3 to 7 percent slopes.
Lamonta sandy clay loam, 3 to 7 percent slopes.
Lamonta sandy clay loam, eroded, 3 to 7 percent slopes.

Suitable uses

Irrigated crops: Alfalfa, oats, barley, wheat, Ladino clover for seed, peas, and vetch.

Dry-farmed crops: Wheat for grain; rye or barley for hay.

Irrigated pasture: Grass-legume mixture.

Suitable rotations

For irrigated areas, suitable rotations include the following: Grain, followed by 2 years of Ladino clover; and grain followed by peas or vetch.

For dry-farmed areas, a suitable rotation consists of grain alternating with summer fallow for 10 years, then 5 or 6 years of crested wheatgrass and bulbous bluegrass.

Suggested fertilization

Fertilize alfalfa and clover with gypsum.

Fertilize clover grown for seed with phosphoric acid (P_2O_5).

Fertilize grain and peas with ammonium sulfate.

Fertilize irrigated pasture with ammonium sulfate.

Irrigation methods

Irrigate by corrugations. Use a very small head of water.

Other management

Apply manure to irrigated grains; use all crop residues.

Divide irrigated pasture into three or four units and rotate grazing; defer grazing of new stands until they are well established; clip to control weeds; harrow to scatter droppings. Plow pasture, sow to grain, and reseed when necessary.

Fallow dry-farmed areas to conserve moisture; while soil is fallow, cultivate to control weeds. Maintain stubble mulch; spread straw and do not burn it; till on contour where possible.

Management subgroup 2G

Subgroup 2G consists of the following moderately deep loams and sandy clay loams that have a clay subsoil:

Lamonta loam, 7 to 12 percent slopes.
Lamonta loam, eroded, 7 to 12 percent slopes.
Lamonta sandy clay loam, 7 to 12 percent slopes.
Lamonta sandy clay loam, eroded, 7 to 12 percent slopes.

Suitable uses

Irrigated crops: Alfalfa, oats, barley, wheat, Ladino clover for seed, peas, and vetch.

Dry-farmed crops: Wheat for grain; rye or barley for hay.

Irrigated pasture.

Suitable rotations

For irrigated areas, suitable rotations include the following: Grain, followed by 2 years of Ladino clover; and grain followed by peas or vetch.

For dry-farmed areas, a suitable rotation consists of grain alternating with summer fallow for 10 years, then 5 or 6 years of crested wheatgrass and bulbous bluegrass.

Suggested fertilization

Fertilize alfalfa and clover with gypsum.

Fertilize clover grown for seed with phosphoric acid (P_2O_5).

Fertilize grain and peas with ammonium sulfate.

Fertilize irrigated pasture with ammonium sulfate.

Irrigation methods

Irrigate with a very small head of water delivered by corrugations.

Other management

Apply manure to irrigated grains; use all crop residues.

Divide irrigated pasture into three or four units and rotate grazing; defer grazing of new stands until they are well established; clip to control weeds; harrow to scatter droppings. Plow pasture, sow to grain, and reseed pasture mixture when necessary.

Fallow dry-farmed areas to conserve moisture; while soil is fallow, cultivate to control weeds. Maintain stubble mulch; spread straw and do not burn it; till on contour where possible.

Management subgroup 2H

Subgroup 2H consists of the following moderately deep loams and sandy clay loams that have a clay subsoil:

Lamonta loam, 12 to 20 percent slopes.
Lamonta loam, eroded, 12 to 20 percent slopes.
Lamonta sandy clay loam, eroded, 12 to 20 percent slopes.

Suitable uses

Dry-farmed crops: Wheat for grain; rye or barley for hay.

Irrigated grass-legume pasture.

Range grazing.

Suitable rotations

For dry-farmed areas, a suitable rotation is grain alternating with summer fallow for 10 years, then 5 or 6 years of crested wheatgrass and bulbous bluegrass.

Suggested fertilization

Fertilize irrigated pasture with ammonium sulfate.

Irrigation methods

Irrigate pasture with a very small head of water delivered by corrugations.

Other management

Fallow dry-farmed areas to conserve moisture; while soil is fallow, cultivate to control weeds. Maintain stubble mulch; spread straw and do not burn it; cultivate on contour where possible.

Divide pasture into three or four units and rotate grazing; defer grazing of new stands until they are well established; clip to control weeds; harrow to scatter droppings.

Regulate stocking of range. Defer grazing until new growth is 3 to 5 inches high; do not graze too short late in fall; graze tracts in rotation; provide adequate feed in winter. Keep stock distributed by fences and by location of water and salt. Seed cleared or burned areas to crested wheatgrass mixed with a little bulbous bluegrass, beardless wheatgrass, and bluebunch wheatgrass.

Management subgroup 2I

Subgroup 2I consists of the following shallow soils that have a clay and clay loam subsoil:

Gem clay loam, shallow, 7 to 12 percent slopes.
Gem clay loam, shallow, eroded, 7 to 12 percent slopes.
Lamonta loam, shallow, 0 to 3 percent slopes.
Lamonta loam, shallow, 3 to 7 percent slopes.
Lamonta loam, shallow, eroded, 3 to 7 percent slopes.
Lamonta loam, shallow, eroded, 7 to 12 percent slopes.
Lamonta sandy clay loam, shallow, 0 to 3 percent slopes.
Lamonta sandy clay loam, shallow, 3 to 7 percent slopes.
Lamonta sandy clay loam, shallow, eroded, 3 to 7 percent slopes.
Lamonta sandy clay loam, shallow, eroded, 7 to 12 percent slopes.
Madras sandy loam, shallow over sandstone, 0 to 3 percent slopes.
Madras sandy loam, shallow over sandstone, 3 to 7 percent slopes.
Madras sandy loam, shallow over sandstone, eroded, 3 to 7 percent slopes.
Madras sandy loam, shallow over sandstone, eroded, 7 to 12 percent slopes.

Suitable uses

Range grazing.
Irrigated grass-legume pasture.
Dry-farmed crops: Wheat for grain; rye and barley for hay.

Suitable rotations

For dry-farmed areas, a suitable rotation is grain alternating with summer fallow for 10 years, followed by 5 or 6 years of crested wheatgrass and bulbous bluegrass.

Suggested fertilization

Fertilize irrigated pasture with ammonium sulfate.

Irrigation methods

Irrigate with a small head of water delivered in strip borders or corrugations.

Other management

Regulate stocking of range. Defer grazing until new growth is 3 to 5 inches high; do not graze too short late in fall; graze tracts in rotation. Keep stock distributed by fences and by location of water and salt. Provide adequate feed in winter. Seed cleared or burned areas to crested wheatgrass mixed with a little bulbous bluegrass, beardless wheatgrass, and bluebunch wheatgrass.

Divide irrigated pasture into three or four units and rotate grazing; do not graze new stands until they are well established; clip pasture to control weeds; harrow pasture to scatter droppings. Plow pasture, use for crops, and reseed pasture when necessary.

Fallow dry-farmed areas to conserve moisture; while soil is fallow, cultivate to control weeds. Maintain stubble mulch; spread straw and do not burn it; plow on contour where possible.

Management Group 3

Management group 3 is not subdivided. It consists of the following soils of the uplands that were derived principally from basalt:

Gem clay loam, eroded, 3 to 12 percent slopes.
Gem clay loam, eroded, 12 to 20 percent slopes.
Gem loam, 3 to 7 percent slopes.
Gem loam, 7 to 12 percent slopes.
Gem loam, eroded, 7 to 12 percent slopes.

Suitable uses

Dry-farmed crops: Wheat for grain; rye and barley for hay.
Range grazing.

Suitable rotations

Grain alternating with summer fallow for 10 years, followed by 5 or 6 years of crested wheatgrass and bulbous bluegrass.

Other management

Use manure and all crop residues; cultivate to control weeds; maintain stubble mulch; spread straw and do not burn it; cultivate on contour where possible.

Regulate stocking of range. Defer grazing until new growth is 3 to 5 inches high; do not graze too short late in fall; graze tracts in rotation; provide adequate winter feed. Keep stock distributed by fences and by location of water and salt. Seed burned or cleared areas to crested wheatgrass mixed with a little bulbous bluegrass, beardless wheatgrass, and bluebunch wheatgrass.

Management Group 4

Management group 4 consists of soils of the bottom lands and alluvial fans. The soils in this group are of one type—Metolius sandy loam. They are placed in 3 subgroups on the basis of slope.

Management subgroup 4A

Subgroup 4A consists of the following soils:

Metolius sandy loam, 0 to 3 percent slopes.
Metolius sandy loam, eroded, 0 to 3 percent slopes.
Metolius sandy loam, terrace position, 0 to 3 percent slopes.

Suitable uses

Irrigated crops: Potatoes, alfalfa, oats, wheat, barley, peas, and vetch; alsike clover, Ladino clover, and red clover for seed or hay.
Dry-farmed crops: Wheat; rye and barley for hay.

Suitable rotations

The following rotations are suitable for irrigated areas:
Grain; alfalfa for 5 years; potatoes for 2 years; red clover or alsike clover, seeded in preceding grain crop and harvested for seed or hay.
Oats or barley, with clover seeded in stubble in August; 2 years of alsike clover or Ladino clover for seed; potatoes.
Oats, barley, or wheat; hairy vetch or peas; potatoes.
Barley or oats, followed by vetch.

A suitable rotation for dry-farmed land consists of grain alternating with summer fallow for 10 years, followed by 5 or 6 years of crested wheatgrass and bulbous bluegrass.

Suggested fertilization

Fertilize alfalfa and clover with gypsum.

Fertilize clover grown for seed with phosphoric acid (P_2O_5).

Fertilize potatoes that follow alfalfa or clover with nitrogen, phosphoric acid, or ammonium sulfate.

Fertilize grain and peas with ammonium sulfate.

Irrigation methods

Irrigate row crops by furrows. Irrigate grains, hay, and pasture in strip borders.

Other management

Apply manure to potatoes, other row crops, and grains; use all crop residues. Fallow dry-farmed areas to conserve moisture; while soil is fallow, cultivate to control weeds. Spread straw and do not burn it; maintain stubble mulch.

Management subgroup 4B

Subgroup 4B consists of the following soils:

Metolius sandy loam, 3 to 7 percent slopes.
Metolius sandy loam, eroded, 3 to 7 percent slopes.
Metolius sandy loam, terrace position, 3 to 7 percent slopes.

Suitable uses

Irrigated crops: Potatoes, alfalfa, oats, wheat, barley, peas, and vetch; alsike clover, Ladino clover, and red clover for seed and hay.

Dry-farmed crops: Wheat or rye and barley for hay.

Suitable rotations

The following rotations are suitable for irrigated areas:

Grain; alfalfa for 5 years; potatoes for 2 years; grain; red clover or alsike clover seeded in preceeding grain crop and harvested for seed or hay.

Oats or barley, with alsike clover or Ladino clover seeded in stubble in August; 2 years of clover for seed; potatoes.

Oats, barley, or wheat; hairy vetch or peas; potatoes.

Barley or oats followed by vetch.

A suitable rotation for dry-farmed areas consists of grain alternating with summer fallow for 10 years, followed by 5 or 6 years of crested wheatgrass and bulbous bluegrass.

Suggested fertilization

Fertilize alfalfa and clover with gypsum.

Fertilize clover grown for seed with phosphoric acid (P_2O_5).

Fertilize potatoes that follow alfalfa or clover with nitrogen, phosphoric acid, and ammonium sulfate.

Fertilize grain and peas with ammonium sulfate.

Irrigation methods

Irrigate row crops by furrows. Irrigate grain, hay, and pasture by corrugations or by flooding from contour laterals.

Other management

For irrigated crops, apply manure and turn under green-manure crops and crop residues.

Fallow dry-farmed areas to conserve moisture; while soil is fallow, cultivate to control weeds. Maintain stubble mulch; spread straw and do not burn it.

Management subgroup 4C

Metolius sandy loam, 7 to 12 percent slopes, is the only soil in subgroup 4C.

Suitable uses

Irrigated crops: Alfalfa, alsike clover, Ladino clover, red clover, oats, barley, or wheat.

Irrigated pasture: Grass-legume mixture.

Dry-farmed crops: Wheat for grain; rye and barley for hay.

Range grazing.

Suitable rotations

For irrigated areas, suitable rotations include the following: Grain followed by 5 or 6 years of alfalfa; and grain followed by 2 or 3 years of clover.

For dry-farmed areas, a suitable rotation consists of grain alternating with summer fallow for 10 years, then 5 or 6 years of crested wheatgrass and bulbous bluegrass.

Suggested fertilization

Fertilize alfalfa and clover with gypsum.

Fertilize clover grown for seed with phosphoric acid (P_2O_5).

Fertilize grain with ammonium sulfate.

Fertilize irrigated pasture with sulfur and phosphoric acid and, where needed, nitrogen.

Irrigation methods

For either crops or pasture, irrigate by corrugations or by flooding from contour laterals.

Other management

Apply manure to grains; use all crop residues. Divide pasture into three or four units and rotate grazing; do not graze new stands until they are well established; clip pasture to control weeds; harrow pasture to scatter droppings. Plow pasture and use for crops, and reseed when necessary.

Fallow dry-farmed areas to conserve moisture; while soil is fallow, cultivate to control weeds. Maintain stubble mulch. Spread straw and do not burn it. Plow on contour where possible. Seed cleared areas to crested wheatgrass mixed with a little bulbous bluegrass, beardless wheatgrass, and bluebunch wheatgrass.

Regulate stocking of range. Defer grazing until new growth is 3 to 5 inches high; do not graze too short late in fall; graze tracts in rotation. Keep stock distributed by fences and by location of water and salt; provide adequate feed in winter. Seed cleared or burned areas to crested wheatgrass mixed with a little bulbous bluegrass, beardless wheatgrass, and bluebunch wheatgrass.

Management Group 5

Management group 5 consists of rough broken land and steep and shallow soils, most of which are not arable. This group is not subdivided.

Agency loam, eroded, 20 to 35 percent slopes.
Madras sandy loam, shallow over sandstone, 12 to 20 percent slopes.
Rough broken land, Era and Deschutes soil materials, 12 to 50 percent slopes.

Suitable use

Range grazing.

Management

Regulate stocking of range. Defer grazing until new growth is 3 to 5 inches high; do not graze too short late in fall; graze tracts in rotation. Keep stock distributed by fences and by location of water and salt; provide adequate feed in winter; reseed where feasible. Seed cleared or burned areas to crested wheatgrass mixed with a little bulbous bluegrass, beardless wheatgrass, bluegrass, and bluebunch wheatgrass.

Management Group 6

Management group 6 consists of the following nonarable stony soils and miscellaneous land types:

Agency loam, stony, 0 to 3 percent slopes.
Agency loam, stony, 3 to 7 percent slopes.
Agency loam, stony, 7 to 12 percent slopes.
Agency loam, stony, 12 to 20 percent slopes.
Agency loam, stony, 20 to 35 percent slopes.
Lamonta loam, stony, 0 to 3 percent slopes.
Lamonta loam, stony, 3 to 7 percent slopes.
Lamonta loam, stony, 7 to 12 percent slopes.
Lamonta sandy clay loam, stony, 0 to 3 percent slopes.
Lamonta sandy clay loam, stony, 3 to 7 percent slopes.
Lamonta sandy clay loam, stony, 7 to 12 percent slopes.
Lamonta sandy clay loam, stony, 12 to 20 percent slopes.
Madras loam, stony, 0 to 3 percent slopes.
Madras loam, stony, 3 to 7 percent slopes.
Madras loam, stony, 7 to 12 percent slopes.
Madras sandy loam, stony, over sandstone, 0 to 3 percent slopes.
Madras sandy loam, stony, over sandstone, 3 to 7 percent slopes.
Madras sandy loam, stony, over sandstone, 7 to 12 percent slopes.
Madras sandy loam, stony, over sandstone, 12 to 20 percent slopes.
Riverwash.
Rough stony land, Agency and Deschutes soil materials, 12 to 60 percent slopes.
Scabland, 0 to 3 percent slopes.
Scabland, 3 to 12 percent slopes.

Suitable use

Range grazing.

Management

Regulate stocking of range. Defer grazing until new growth is 3 to 5 inches high; do not graze too short late in fall; graze tracts in rotation. Keep stock distributed by fences and by location of water and salt; provide adequate winter feed. Seed cleared or burned areas to crested wheatgrass mixed with a little bulbous bluegrass, beardless wheatgrass, and bluebunch wheatgrass.

Estimated Yields

Table 3, on estimated yields, was compiled from data obtained at the time of the survey. It gives, for each soil and miscellaneous land type mapped in the Deschutes Area, estimated average yields of the principal crops under ordinary management and improved management. The figures in table 3 are estimates of the average yields that can be expected over a period of several years. Yields on any given soil will be higher than the estimated average in some years and lower in others, depending on weather and management.

The estimates are based on observations of growing crops, on information obtained through interviews with farmers in the Area and with the county agricultural agent, on agricultural planning reports prepared by committees of farmers, on data from the agricultural conservation program, and on data from the Federal census.

That part of the Area that is in Jefferson County will be brought under irrigation for the first time when the facilities of the Deschutes Irrigation Project are finished. It has been assumed that, after 4 or 5 years of irrigation, the soils in this part of the Area will produce about as much as similar soils already under irrigation in Deschutes County and elsewhere.

The A columns in table 3 give average yields under ordinary management, that is, the level of management practiced by most farmers in the Area. The B columns give the average yields that can be expected under the type of management practiced by those farmers of the Area who consistently obtain high yields.

After a farmer has determined from the soil map the kinds of soil on his farm, he can use table 3 to find out whether he is getting as much as he can reasonably expect from his soils. If yields are consistently less than those listed in the B columns, it is likely that better yields could be obtained by improved management. Under the best possible management, yields would be even higher that those in the B columns if the weather were favorable.

The table of estimated yields cannot be used to calculate total production of a crop, because it does not show what proportion of the acreage of a particular soil is used for a specified crop. Neither should the estimates of average yields be considered an indication of land value, which depends on prices, distance to markets, and other economic factors.

TABLE 3.—*Estimated average acre yields of*

[Yields in columns A are to be expected under ordinary management; those in columns B, under improved management.[1] Absence of

Soil or land type	Map symbol	Irrigated					
		Potatoes		Alfalfa		Alsike clover seed	
		A	B	A	B	A	B
		100-lb. bags	*100-lb. bags*	*Tons*	*Tons*	*Bu.*	*Bu.*
Agency gravelly loam, 0 to 3 percent slopes [3]	Aa	120	190	2. 9	4. 3	5. 5	10
Agency gravelly loam, 3 to 7 percent slopes [3]	Ab	110	180	2. 8	4. 2	5	9
Agency gravelly loam, 7 to 12 percent slopes[3]	Ad	90	150	2. 3	3. 3	4	7
Agency gravelly loam, eroded, 3 to 7 percent slopes [3]	Ac	90	150	2. 3	3. 4	4	7
Agency gravelly loam, eroded, 7 to 12 percent slopes [3]	Ae	75	130	2. 0	3. 0	3. 5	6
Agency loam, 0 to 3 percent slopes	Af	140	210	3	4. 5	6	11
Agency loam, 3 to 7 percent slopes	Ah	130	200	3	4. 5	5. 5	10
Agency loam, 7 to 12 percent slopes	Al	100	160	2. 5	3. 5	5	9
Agency loam, 12 to 20 percent slopes	Am	--------	--------	--------	--------	--------	--------
Agency loam, eroded, 0 to 3 percent slopes	Ag	130	200	3	4. 5	5. 5	10
Agency loam, eroded, 3 to 7 percent slopes	Ak	120	190	2. 8	4. 2	5	9
Agency loam, eroded, 20 to 35 percent slopes	An	--------	--------	--------	--------	--------	--------
Agency loam, stony, 0 to 3 percent slopes	Ao	--------	--------	--------	--------	--------	--------
Agency loam, stony, 3 to 7 percent slopes	Ap	--------	--------	--------	--------	--------	--------
Agency loam, stony, 7 to 12 percent slopes	Ar	--------	--------	--------	--------	--------	--------
Agency loam, stony, 12 to 20 percent slopes	As	--------	--------	--------	--------	--------	--------
Agency loam, stony, 20 to 35 percent slopes	At	--------	--------	--------	--------	--------	--------
Agency sandy loam, 0 to 3 percent slopes [3]	Au	125	195	2. 9	4. 3	5. 5	10
Agency sandy loam, 3 to 7 percent slopes [3]	Aw	115	185	2. 8	4. 2	5	9
Agency sandy loam, eroded, 0 to 3 percent slopes [3]	Av	110	170	2. 8	4. 2	5	9
Agency sandy loam, eroded, 3 to 7 percent slopes [3]	Ax	100	160	2. 6	4. 0	4	7
Deschutes coarse sandy loam, over sandy material, 0 to 3 percent slopes.	Da	100	170	2. 1	3. 0	3. 5	6
Deschutes loam, stony, 0 to 3 percent slopes	Db	--------	--------	2. 7	4. 0	5	8
Deschutes loamy coarse sand, over gravelly material, 0 to 3 percent slopes.	Dc	80	135	2. 3	3. 2	4	7
Deschutes loamy coarse sand, over gravelly material, 3 to 7 percent slopes.	Dd	70	125	2. 2	3. 0	3. 5	6
Deschutes loamy sand, 0 to 3 percent slopes	De	90	150	2. 3	3. 2	4	7
Deschutes loamy sand, 3 to 7 percent slopes	Dg	80	135	2. 2	3. 0	3. 5	6
Deschutes loamy sand, 7 to 12 percent slopes	Dh	50	100	2. 0	2. 8	3	5
Deschutes loamy sand, eroded, 0 to 3 percent slopes	Df	85	150	2. 3	3. 2	4	7
Deschutes loamy sand, over cinders, 0 to 3 percent slopes	Dk	80	145	2. 1	3. 1	3. 5	6
Deschutes loamy sand, over cinders, 3 to 7 percent slopes	Dl	70	130	2. 0	2. 9	3	5
Deschutes loamy sand, over cinders, eroded, 3 to 7 percent slopes	Dm	60	125	1. 9	2. 9	3	5
Deschutes loamy sand, over cobbly material, 0 to 3 percent slopes	Dn	80	145	2. 1	3. 1	3. 5	6
Deschutes loamy sand, over gravelly material, 0 to 3 percent slopes	Do	90	150	2. 5	3. 5	4. 5	8
Deschutes loamy sand, over gravelly material, 3 to 7 percent slopes	Dp	80	135	2. 3	3. 3	4	7
Deschutes loamy sand, over semicemented sandy material, 0 to 3 percent slopes.	Dr	90	150	2. 4	3. 4	4	7
Deschutes loamy sand, over semicemented sandy material, 3 to 7 percent slopes.	Ds	80	135	2. 2	3. 1	3. 5	6
Deschutes loamy sand, over semicemented sandy material, 7 to 12 percent slopes.	Dt	50	100	2. 0	2. 8	3	5
Deschutes sandy loam, 0 to 3 percent slopes	Du	115	185	2. 8	4. 0	5	9
Deschutes sandy loam, 3 to 7 percent slopes	Dv	100	170	2. 7	3. 7	4. 5	8
Deschutes sandy loam, 7 to 12 percent slopes	Dw	70	130	2. 3	3. 0	4	7
Deschutes sandy loam, 12 to 20 percent slopes	Dy	--------	--------	--------	--------	--------	--------
Deschutes sandy loam, deep, 0 to 3 percent slopes	Dz	130	200	3. 5	4. 5	6	10
Deschutes sandy loam, deep, 3 to 7 percent slopes	Dea	110	180	3. 4	4. 3	5	8
Deschutes sandy loam, deep over cinders, 0 to 3 percent slopes	Deb	130	200	3. 5	4. 5	6	10
Deschutes sandy loam, eroded, 7 to 12 percent slopes	Dx	60	130	2. 2	3. 0	4	7
Deschutes sandy loam, over cinders, 0 to 3 percent slopes	Dec	110	185	2. 7	4. 0	4. 5	9
Deschutes sandy loam, over cinders, 3 to 7 percent slopes	Ded	90	170	2. 5	3. 7	4	8
Deschutes sandy loam, over cinders, eroded, 3 to 7 percent slopes	Del	80	170	2. 5	3. 7	4	8
Deschutes sandy loam, over semicemented sandy material, 0 to 3 percent slopes.	Deo	105	175	2. 8	4. 0	5	9
Deschutes sandy loam, over semicemented sandy material, 3 to 7 percent slopes.	Des	90	160	2. 7	3. 7	4. 5	8
Deschutes sandy loam, over semicemented sandy material, 7 to 12 percent slopes.	Dla	60	120	2. 3	3. 0	4	7
Deschutes sandy loam, over semicemented sandy material, eroded, 12 to 20 percent slopes.	Dlb	--------	--------	--------	--------	--------	--------
Deschutes sandy loam, shallow, 0 to 3 percent slopes	Dlc	80	150	1	2. 0	3	5

See footnotes at end of table.

principal crops under two levels of management

a yield figure indicates the crop is not commonly grown on the soil and is not considered suitable for it under the management specified]

Irrigated												Nonirrigated			
Ladino clover seed		Hairy vetch seed		Barley		Oats		Spring wheat		Pasture		Winter wheat		Native range	
A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Cow-acre-days* [2]	*Cow-acre-days* [2]	*Bu.*	*Bu.*	*Cow-acre-days* [2]	*Cow-acre-days* [2]
2. 3	4. 0	8	14	35	60	40	70	30	40	115	230	9. 5	11	3	6
2. 0	3. 8	7	13	30	50	35	60	25	35	105	210	9. 5	11	3	6
1. 7	3. 5	5	10	25	45	30	55	20	30	90	180	8	9	2. 5	5
1. 8	3. 5	5	11	25	45	30	55	20	30	90	180	9	10	2. 5	5
1. 5	3. 0	4	9	20	40	25	45	17	26	80	160	8	9	2	4
2. 5	4. 5	8	14	45	70	50	80	38	50	130	250	11	12	3. 5	7
2. 3	4. 2	7	13	42	65	47	75	35	46	120	230	11	12	3. 5	7
2. 0	4. 0	6	11	35	55	40	65	30	40	100	190	10	11	3	6
------	------	------	------	------	------	------	------	------	------	80	140	9	10	2. 5	5
2. 3	4. 2	7	13	42	65	47	75	35	46	130	250	11	12	3. 5	7
2. 0	4. 0	6	12	37	60	40	65	30	40	110	220	10	11	3	6
------	------	------	------	------	------	------	------	------	------	------	------	------	------	2	3. 5
------	------	------	------	------	------	------	------	------	------	110	200	------	------	3	6
------	------	------	------	------	------	------	------	------	------	100	190	------	------	3	6
------	------	------	------	------	------	------	------	------	------	80	140	------	------	2. 5	5
------	------	------	------	------	------	------	------	------	------	60	120	------	------	2	4
------	------	------	------	------	------	------	------	------	------	------	------	------	------	2	3. 5
2. 5	4. 5	7	13	35	60	40	70	30	40	115	230	9. 5	11	3	6
2. 3	4. 2	6	12	30	50	35	60	25	35	105	210	9. 5	11	3	6
2. 3	4. 2	6	12	30	50	35	60	25	35	115	230	9. 5	11	3	6
2. 0	4. 0	5	11	25	45	30	55	20	30	90	180	9	10	2. 5	5
1. 7	3. 0	5	9	30	55	35	65	25	35	85	170	------	------	2	3. 5
------	------	8	14	40	65	45	75	28	38	120	230	------	------	3	6
1. 6	2. 8	5	9	26	48	32	60	23	30	90	180	------	------	2	3. 5
1. 4	2. 5	4	7	23	40	26	55	19	26	80	160	------	------	2	3. 5
1. 7	3. 0	5	9	27	50	35	60	23	30	90	180	------	------	2	3. 5
1. 5	2. 6	4	7	24	42	30	55	19	26	80	160	------	------	2	3. 5
1. 3	2. 3	3	6	20	35	25	45	16	23	60	120	------	------	2	3. 5
1. 7	3. 0	5	9	24	50	30	60	20	30	90	180	------	------	2	3. 5
1. 6	2. 8	5	9	27	50	35	60	23	30	80	170	------	------	2	3. 5
1. 4	2. 5	4	7	23	40	30	55	18	25	70	150	------	------	2	3. 5
1. 3	2. 5	4	7	20	40	25	50	16	25	60	150	------	------	2	3. 5
1. 6	2. 8	5	9	27	50	35	60	23	30	80	170	------	------	2	3. 5
1. 7	3. 0	5	9	27	50	35	60	23	30	90	180	------	------	2	3. 5
1. 5	2. 6	4	7	24	42	30	55	19	26	80	160	------	------	2	3. 5
1. 7	3. 0	5	9	27	50	35	60	23	30	90	180	------	------	2	3. 5
1. 5	2. 6	4	7	24	42	30	55	19	26	80	160	------	------	2	3. 5
1. 3	2. 3	3	6	20	35	25	45	16	23	60	120	------	------	2	3. 5
1. 9	3. 3	7	13	35	60	40	70	28	38	110	225	------	------	2	3. 5
1. 8	3. 0	6	11	30	50	35	60	23	30	95	200	------	------	2	3. 5
1. 5	2. 7	5	9	25	45	30	55	18	27	75	150	------	------	2	3. 5
------	------	------	------	------	------	------	------	------	------	50	100	------	------	2	3. 5
2. 1	3. 5	8	14	37	62	42	72	30	40	125	250	------	------	2. 5	4
1. 9	3. 1	7	12	32	52	37	62	24	32	110	215	------	------	2	3. 5
2. 1	3. 5	8	14	37	62	42	72	30	40	125	250	------	------	2. 5	4
1. 4	2. 6	5	9	21	40	25	45	15	24	70	150	------	------	2	3. 5
1. 7	3. 3	6	13	32	60	37	70	25	38	100	225	------	------	2	3. 5
1. 5	3. 0	5	11	27	50	32	60	20	30	85	200	------	------	2	3. 5
1. 5	3. 0	5	11	24	45	30	55	18	27	80	200	------	------	2	3. 5
1. 9	3. 3	7	13	35	60	40	70	28	38	110	225	------	------	2	3. 5
1. 8	3. 0	6	11	30	50	35	60	23	30	95	200	------	------	2	3. 5
1. 5	2. 7	5	9	25	45	30	55	18	27	75	150	------	------	2	3. 5
------	------	------	------	------	------	------	------	------	------	50	100	------	------	2	3. 5
1	2	4	7	20	35	25	40	15	25	60	130	------	------	1	2
------	------	------	------	15	30	20	35	12	20	40	100	------	------	1	2

TABLE 3.—*Estimated average acre yields of principal*

Soil or land type	Map symbol	Irrigated					
		Potatoes		Alfalfa		Alsike clover seed	
		A	B	A	B	A	B
		100-lb. bags	*100-lb. bags*	*Tons*	*Tons*	*Bu.*	*Bu.*
Deschutes sandy loam, shallow, 3 to 7 percent slopes	Dle	60	120	----	----	----	----
Deschutes sandy loam, shallow over cinders, 0 to 3 percent slopes	Dlo	70	140	0. 8	1. 8	2. 5	4
Deschutes sandy loam, shallow over cinders, eroded, 3 to 7 percent slopes.	Dls	40	100	----	----	----	----
Deschutes sandy loam, stony, 0 to 3 percent slopes	Dsa	90	160	2. 5	3. 5	4. 5	8
Deschutes sandy loam, stony, 3 to 7 percent slopes	Dsb	75	140	2. 3	3. 3	4	7
Deschutes sandy loam, stony, 7 to 12 percent slopes	Dsc	----	----	2. 0	2. 9	3. 5	6
Deschutes sandy loam, stony, over cinders, 3 to 7 percent slopes	Dsd	70	135	2. 1	3. 1	3. 5	6
Deschutes sandy loam, stony, over semicemented sandy material, 0 to 3 percent slopes.	Dse	80	150	2. 5	3. 5	4. 5	8
Deschutes sandy loam, stony, over semicemented sandy material, 3 to 7 percent slopes.	Dsl	65	120	2. 3	3. 3	4	7
Deschutes sandy loam, stony, over semicemented sandy material, 7 to 12 percent slopes.	Dso	----	----	2. 0	2. 9	3. 5	6
Era sandy loam, 0 to 3 percent slopes [3]	Ea	135	205	2. 9	4. 3	5. 5	10
Era sandy loam, 3 to 7 percent slopes [3]	Ec	120	190	2. 8	4. 2	5	9
Era sandy loam, 7 to 12 percent slopes [3]	Ee	100	160	2. 3	3. 5	4. 5	8
Era sandy loam, 12 to 20 percent slopes [3]	Eg	----	----	----	----	----	----
Era sandy loam, eroded, 0 to 3 percent slopes [3]	Eb	125	190	2. 8	4. 2	5	9
Era sandy loam, eroded, 3 to 7 percent slopes [3]	Ed	110	175	2. 6	4. 0	4. 5	8
Era sandy loam, eroded, 7 to 12 percent slopes [3]	Ef	90	150	2. 3	3. 3	4	7
Era sandy loam, eroded, 12 to 20 percent slopes [3]	Eh	----	----	----	----	----	----
Gem clay loam, eroded, 3 to 12 percent slopes	Ga	----	----	----	----	----	----
Gem clay loam, eroded, 12 to 20 percent slopes	Gb	----	----	----	----	----	----
Gem clay loam, shallow, 7 to 12 percent slopes	Gc	----	----	----	----	----	----
Gem clay loam, shallow, eroded, 7 to 12 percent slopes	Gd	----	----	----	----	----	----
Gem loam, 3 to 7 percent slopes	Ge	----	----	----	----	----	----
Gem loam, 7 to 12 percent slopes	Go	----	----	----	----	----	----
Gem loam, eroded, 7 to 12 percent slopes	Gs	----	----	----	----	----	----
Laidlaw sandy loam, 0 to 3 percent slopes	La	95	160	2. 5	3. 7	5	9
Laidlaw sandy loam, 3 to 7 percent slopes	Lb	80	140	2. 4	3. 5	4. 5	8
Laidlaw sandy loam, 7 to 12 percent slopes	Lc	50	100	2. 0	3. 0	4	7
Laidlaw sandy loam, eroded, 7 to 12 percent slopes	Ld	40	95	2. 0	3. 0	3. 5	7
Laidlaw sandy loam, eroded, 12 to 20 percent slopes	Le	----	----	----	----	----	----
Lamonta loam, 0 to 3 percent slopes [3]	Lf	75	120	2. 5	3. 5	5	9
Lamonta loam, 3 to 7 percent slopes [3]	Lh	60	100	2. 4	3. 4	4. 5	8
Lamonta loam, 7 to 12 percent slopes [3]	Lm	40	75	2. 0	3. 0	4	7
Lamonta loam, 12 to 20 percent slopes [3]	Lo	----	----	----	----	----	----
Lamonta loam, eroded, 0 to 3 percent slopes [3]	Lg	60	100	2. 4	3. 4	4. 5	9
Lamonta loam, eroded, 3 to 7 percent slopes [3]	Lk	50	85	2. 3	3. 3	4	8
Lamonta loam, eroded, 7 to 12 percent slopes [3]	Ln	----	----	1. 8	2. 8	3. 5	6
Lamonta loam, eroded, 12 to 20 percent slopes [3]	Lp	----	----	----	----	----	----
Lamonta loam, shallow, 0 to 3 percent slopes [3]	Lr	50	85	----	----	----	----
Lamonta loam, shallow, 3 to 7 percent slopes [3]	Ls	----	----	----	----	----	----
Lamonta loam, shallow, eroded, 3 to 7 percent slopes [3]	Lt	----	----	----	----	----	----
Lamonta loam, shallow, eroded, 7 to 12 percent slopes [3]	Lu	----	----	----	----	----	----
Lamonta loam, stony, 0 to 3 percent slopes [3]	Lv	----	----	----	----	----	----
Lamonta loam, stony, 3 to 7 percent slopes [3]	Lw	----	----	----	----	----	----
Lamonta loam, stony, 7 to 12 percent slopes [3]	Lx	----	----	----	----	----	----
Lamonta sandy clay loam, 0 to 3 percent slopes	Ly	----	----	2. 5	3. 5	5	9
Lamonta sandy clay loam, 3 to 7 percent slopes	Lea	----	----	2. 4	3. 4	4. 5	8
Lamonta sandy clay loam, 7 to 12 percent slopes	Led	----	----	2. 0	3. 0	4	7
Lamonta sandy clay loam, eroded, 0 to 3 percent slopes	Lz	----	----	2. 4	3. 4	4. 5	9
Lamonta sandy clay loam, eroded, 3 to 7 percent slopes	Lec	----	----	2. 3	3. 3	4	8
Lamonta sandy clay loam, eroded, 7 to 12 percent slopes	Leh	----	----	1. 8	2. 8	3. 5	6
Lamonta sandy clay loam, eroded, 12 to 20 percent slopes	Ler	----	----	----	----	----	----
Lamonta sandy clay loam, shallow, 0 to 3 percent slopes	Lev	----	----	----	----	----	----
Lamonta sandy clay loam, shallow, 3 to 7 percent slopes	Lsa	----	----	----	----	----	----
Lamonta sandy clay loam, shallow, eroded, 3 to 7 percent slopes	Lsb	----	----	----	----	----	----
Lamonta sandy clay loam, shallow, eroded, 7 to 12 percent slopes	Lsc	----	----	----	----	----	----
Lamonta sandy clay loam, stony, 0 to 3 percent slopes	Lsd	----	----	----	----	----	----
Lamonta sandy clay loam, stony, 3 to 7 percent slopes	Lse	----	----	----	----	----	----
Lamonta sandy clay loam, stony, 7 to 12 percent slopes	Lsl	----	----	----	----	----	----
Lamonta sandy clay loam, stony, 12 to 20 percent slopes	Lso	----	----	----	----	----	----
Madras loam, 0 to 3 percent slopes [3]	Ma	120	190	3	4. 5	6	11
Madras loam, 3 to 7 percent slopes [3]	Mc	110	175	3	4. 5	5. 5	10

See footnotes at end of table.

crops under two levels of management—Continued

Irrigated												Nonirrigated			
Ladino clover seed		Hairy vetch seed		Barley		Oats		Spring wheat		Pasture		Winter wheat		Native range	
A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Cow-acre-days* [2]	*Cow-acre-days* [2]	*Bu.*	*Bu.*	*Cow-acre-days* [2]	*Cow-acre-days* [2]
0. 8	1. 8	3	6	18	32	22	36	12	22	50	110	------	------	1	2
------	------	------	------	12	25	17	30	10	18	30	80	------	------	1	2
1. 8	3. 0	6	11	30	50	35	60	23	30	100	220	------	------	2	3. 5
1. 7	2. 8	5	9	25	40	30	50	18	25	85	190	------	------	2	3. 5
1. 4	2. 6	4	8	20	30	25	43	15	20	70	140	------	------	2	3. 5
1. 5	2. 6	4	8	22	35	27	45	15	22	75	170	------	------	2	3. 5
1. 8	3. 0	6	11	30	50	35	60	23	30	100	220	------	------	2	3. 5
1. 7	2. 8	5	9	25	40	30	50	18	25	85	190	------	------	2	3. 5
1. 4	2. 6	4	8	20	30	25	43	15	20	70	140	------	------	2	3. 5
2. 5	4. 5	8	14	35	60	40	70	30	40	115	230	9. 5	11	3	6
2. 3	4. 2	7	13	30	50	35	60	25	35	105	210	9. 5	11	3	6
2. 0	4. 0	6	11	25	45	30	55	20	30	90	170	8. 5	10	3	6
------	------	------	------	------	------	------	------	------	------	80	130	7. 5	9	2. 5	5
2. 3	4. 2	7	13	30	50	35	60	25	35	115	230	9	11	3	6
2. 0	4. 0	6	11	25	45	30	55	20	30	90	180	9	11	3	6
1. 7	3. 5	5	9	22	42	27	50	17	26	80	160	8	10	2. 5	5
------	------	------	------	------	------	------	------	------	------	65	120	7	8	2. 5	5
------	------	------	------	------	------	------	------	------	------	------	------	15	17	5	7
------	------	------	------	------	------	------	------	------	------	------	------	12	15	4	6
------	------	------	------	------	------	------	------	------	------	------	------	10	12	4	6
------	------	------	------	------	------	------	------	------	------	------	------	9	11	3	5
------	------	------	------	------	------	------	------	------	------	------	------	16	18	6	8
------	------	------	------	------	------	------	------	------	------	------	------	15	17	5	7
------	------	------	------	------	------	------	------	------	------	------	------	14	16	5	7
1. 9	3. 3	7	13	35	60	40	70	27	37	100	210	------	------	2	3. 5
1. 8	3. 0	6	11	30	50	35	60	23	30	90	190	------	------	2	3. 5
1. 5	2. 7	5	9	25	45	30	55	18	27	70	140	------	------	2	3. 5
1. 4	2. 7	4	8	22	43	28	52	16	25	65	130	------	------	2	3. 5
------	------	------	------	------	------	------	------	------	------	45	90	------	------	1. 5	2. 5
2. 3	4. 0	8	14	45	70	50	80	38	50	130	250	[4] 11	[4] 12	[4] 3. 5	[4] 7
2. 2	3. 8	7	13	42	65	47	75	35	46	120	230	[4] 11	[4] 12	[4] 3. 5	[4] 7
1. 7	3. 0	5	10	35	55	40	65	30	40	100	190	[4] 10	[4] 11	[4] 3	[4] 6
------	------	------	------	------	------	------	------	------	------	80	140	[4] 9	[4] 10	[4] 2. 5	[4] 5
2. 2	3. 8	7	13	42	65	47	75	35	46	130	250	[4] 11	[4] 12	[4] 3. 5	[4] 7
2. 1	3. 6	6	11	37	60	40	65	30	40	110	220	[4] 10	[4] 11	[4] 3	[4] 6
1. 5	2. 8	4	7	30	50	35	55	25	35	90	170	[4] 9	[4] 10	[4] 3	[4] 6
------	------	------	------	------	------	------	------	------	------	70	120	[4] 8	[4] 9	[4] 2. 5	[4] 5
1. 5	2. 5	6	10	30	45	35	50	20	30	110	200	7	8	3	6
1. 3	2. 0	5	9	25	40	30	40	17	22	100	180	6	7	3	6
1. 1	1. 8	4	7	20	35	25	35	15	20	90	160	6	7	3	6
------	------	------	------	------	------	------	------	------	------	70	150	5	6	2. 5	5
------	------	------	------	------	------	------	------	------	------	120	220	------	------	3. 5	7
------	------	------	------	------	------	------	------	------	------	110	200	------	------	3. 5	7
------	------	------	------	------	------	------	------	------	------	100	180	------	------	3	6
2. 3	4. 0	8	14	45	70	50	80	38	50	130	250	[4] 11	[4] 12	[4] 3. 5	[4] 7
2. 2	3. 8	7	13	42	65	47	75	35	46	120	230	[4] 11	[4] 12	[4] 3. 5	[4] 7
1. 7	3. 0	5	10	35	55	40	65	30	40	100	190	[4] 10	[4] 11	[4] 3	[4] 6
2. 2	3. 8	7	13	42	65	47	75	35	46	130	250	[4] 11	[4] 12	[4] 3. 5	[4] 7
2. 1	3. 6	6	11	37	60	40	65	30	40	110	220	[4] 10	[4] 11	[4] 3	[4] 6
1. 5	2. 8	4	7	30	50	35	55	25	35	90	170	[4] 9	[4] 10	[4] 3	[4] 6
------	------	------	------	------	------	------	------	------	------	70	120	[4] 8	[4] 9	[4] 2. 5	[4] 5
1. 5	2. 5	6	10	30	45	35	50	20	30	110	200	7	8	3	6
1. 3	2. 0	5	9	25	40	30	40	17	22	100	180	6	7	3	6
1. 1	1. 8	4	7	20	35	25	35	15	20	90	160	6	7	3	6
------	------	------	------	------	------	------	------	------	------	70	150	5	6	2. 5	5
------	------	------	------	------	------	------	------	------	------	120	220	------	------	3. 5	7
------	------	------	------	------	------	------	------	------	------	110	200	------	------	3. 5	7
------	------	------	------	------	------	------	------	------	------	100	180	------	------	3	6
------	------	------	------	------	------	------	------	------	------	70	120	------	------	2. 5	5
2. 5	4. 5	8	14	45	70	50	80	38	50	130	250	11	12	3. 5	7
2. 3	4. 2	7	13	42	65	47	75	35	46	120	230	11	12	3. 5	7

TABLE 3.—*Estimated average acre yields of principal*

Soil or land type	Map symbol	Irrigated					
		Potatoes		Alfalfa		Alsike clover seed	
		A	B	A	B	A	B
		100-lb. bags	*100-lb. bags*	*Tons*	*Tons*	*Bu.*	*Bu.*
Madras loam, 7 to 12 percent slopes[3]	Me	90	150	2. 5	3. 5	5	9
Madras loam, eroded, 0 to 3 percent slopes[3]	Mb	110	180	3	4. 5	5. 5	10
Madras loam, eroded, 3 to 7 percent slopes[3]	Md	100	170	2. 8	4. 2	5	9
Madras loam, eroded, 7 to 12 percent slopes[3]	Mf	80	140	2. 3	3. 5	4. 5	8
Madras loam, over sandstone, 0 to 3 percent slopes[3]	Mg	140	210	3. 2	4. 7	6. 5	12
Madras loam, over sandstone, 3 to 7 percent slopes[3]	Mk	130	200	3. 2	4. 7	6	11
Madras loam, over sandstone, eroded, 0 to 3 percent slopes[3]	Mh	130	200	3. 2	4. 7	6	11
Madras loam, over sandstone, eroded, 3 to 7 percent slopes[3]	Ml	120	190	3. 1	4. 6	5. 5	10
Madras loam, stony, 0 to 3 percent slopes[3]	Mm	--------	--------	--------	--------	--------	--------
Madras loam, stony, 3 to 7 percent slopes[3]	Mn	--------	--------	--------	--------	--------	--------
Madras loam, stony, 7 to 12 percent slopes[3]	Mo	--------	--------	--------	--------	--------	--------
Madras loamy sand, over sandstone, 3 to 7 percent slopes[3]	Mp	100	160	2. 5	3. 8	4. 5	8
Madras loamy sand, over sandstone, eroded, 3 to 7 percent slopes[3]	Mr	90	150	2. 4	3. 7	4	8
Madras sandy loam, 0 to 3 percent slopes[3]	Ms	120	190	2. 8	4. 2	5	9
Madras sandy loam, 3 to 7 percent slopes[3]	Mu	110	175	2. 7	4. 1	4. 5	8
Madras sandy loam, 7 to 12 percent slopes[3]	My	90	150	2. 3	3. 8	4	7
Madras sandy loam, deep over sandstone, 0 to 3 percent slopes[3]	Mea	140	210	3. 5	5. 0	6. 5	12
Madras sandy loam, deep over sandstone, 3 to 7 percent slopes[3]	Meb	130	200	3. 5	5. 0	6	11
Madras sandy loam, deep over sandstone, eroded, 3 to 7 percent slopes[3].	Mec	120	190	3. 3	5. 0	5. 5	11
Madras sandy loam, eroded, 0 to 3 percent slopes[3]	Mt	110	180	2. 7	4. 2	4. 5	9
Madras sandy loam, eroded, 3 to 7 percent slopes[3]	Mv	100	170	2. 6	4. 1	4	7
Madras sandy loam, eroded, 7 to 12 percent slopes[3]	Mz	80	140	2. 3	3. 8	3. 5	6
Madras sandy loam, over sandstone, 0 to 3 percent slopes[3]	Med	140	210	3. 0	4. 5	5. 5	10
Madras sandy loam, over sandstone, 3 to 7 percent slopes[3]	Meh	130	200	2. 9	4. 3	5	9
Madras sandy loam, over sandstone, 7 to 12 percent slopes[3]	Meo	110	175	2. 5	4. 0	4. 5	8
Madras sandy loam, over sandstone, 12 to 20 percent slopes[3]	Mla	--------	--------	--------	--------	--------	--------
Madras sandy loam, over sandstone, eroded, 0 to 3 percent slopes[3]	Mef	130	200	3. 0	4. 5	5	10
Madras sandy loam, over sandstone, eroded, 3 to 7 percent slopes[3]	Mel	120	190	2. 9	4. 3	4. 5	9
Madras sandy loam, over sandstone, eroded, 7 to 12 percent slopes[3]	Mes	90	150	2. 5	4. 0	4	7
Madras sandy loam, over sandstone, eroded, 12 to 20 percent slopes[3]	Mlc	--------	--------	--------	--------	--------	--------
Madras sandy loam, shallow over sandstone, 0 to 3 percent slopes[3]	Mld	80	150	1. 5	2. 5	3	5
Madras sandy loam, shallow over sandstone, 3 to 7 percent slopes[3]	Mle	60	110	1. 5	2. 5	2. 5	4
Madras sandy loam, shallow over sandstone, 12 to 20 percent slopes[3]	Moc	--------	--------	--------	--------	--------	--------
Madras sandy loam, shallow over sandstone, eroded, 3 to 7 percent slopes[3].	Mlo	50	100	1. 5	2. 5	2. 5	4
Madras sandy loam, shallow over sandstone, eroded, 7 to 12 percent slopes[3].	Mls	--------	--------	--------	--------	--------	--------
Madras sandy loam, stony, over sandstone, 0 to 3 percent slopes[3]	Mod	--------	--------	--------	--------	--------	--------
Madras sandy loam, stony, over sandstone, 3 to 7 percent slopes[3]	Moe	--------	--------	--------	--------	--------	--------
Madras sandy loam, stony, over sandstone, 7 to 12 percent slopes[3]	Mol	--------	--------	--------	--------	--------	--------
Madras sandy loam, stony, over sandstone, 12 to 20 percent slopes[3]	Mos	--------	--------	--------	--------	--------	--------
Metolius sandy loam, 0 to 3 percent slopes[3]	Mta	140	210	4. 0	5. 5	7	13
Metolius sandy loam, 3 to 7 percent slopes[3]	Mtd	130	200	3. 9	5. 0	6. 5	12
Metolius sandy loam, 7 to 12 percent slopes[3]	Mts	100	160	3. 5	4. 5	5. 5	10
Metolius sandy loam, eroded, 0 to 3 percent slopes[3]	Mtc	130	195	4. 0	5. 5	7	13
Metolius sandy loam, eroded, 3 to 7 percent slopes[3]	Mte	115	185	3. 6	5. 0	5. 5	11
Metolius sandy loam, terrace position, 0 to 3 percent slopes[3]	Mtl	140	210	3. 5	4. 5	6	10
Metolius sandy loam, terrace position, 3 to 7 percent slopes[3]	Mto	130	200	3. 4	4. 4	5. 5	11
Odin clay loam, 0 to 3 percent slopes	Oa	--------	--------	--------	--------	4	7
Odin clay loam, 3 to 7 percent slopes[3]	Ob	--------	--------	--------	--------	4	7
Odin sandy loam, 0 to 3 percent slopes	Oc	115	185	--------	--------	4	7
Redmond clay loam, 0 to 3 percent slopes	Ra	--------	--------	2. 5	3. 5	5	9
Redmond loam, 0 to 3 percent slopes	Rb	135	200	2. 7	3. 8	5	9
Redmond sandy loam, 0 to 3 percent slopes	Rc	125	195	2. 7	3. 8	5	9
Redmond sandy loam, 3 to 7 percent slopes	Rd	110	180	2. 8	4. 2	4. 5	8
Redmond sandy loam, deep, 0 to 3 percent slopes	Re	125	195	2. 9	4. 3	5. 5	10
Riverwash	Rk	--------	--------	--------	--------	--------	--------
Rough broken land, Era and Deschutes soil materials, 12 to 50 percent slopes.	Ro	--------	--------	--------	--------	--------	--------
Rough stony land, Agency and Deschutes soil materials, 12 to 60 percent slopes.	Rs	--------	--------	--------	--------	--------	--------
Scabland, 0 to 3 percent slopes	Sa	--------	--------	--------	--------	--------	--------
Scabland, 3 to 12 percent slopes	Sb	--------	--------	--------	--------	--------	--------
Volcanic ash, 0 to 3 percent slopes[3]	Vo	60	100	2. 0	3. 0	3	5

[1] Ordinary management is the level of management practiced by most farmers in the Area. Improved management is the type of management practiced by those farmers who consistently obtain high yields.

[2] "Cow-acre-days" is a term used to express the carrying capacity of pasture or range. It equals the number of days of grazing 1 acre will provide for 1 animal unit in a year, without injury to the sod. One animal unit is a mature cow, steer, or horse, or five mature sheep.

crops under two levels of management—Continued

Irrigated												Nonirrigated			
Ladino clover seed		Hairy vetch seed		Barley		Oats		Spring wheat		Pasture		Winter wheat		Native range	
A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Cow-acre-days* [2]	*Cow-acre-days* [2]	*Bu.*	*Bu.*	*Cow-acre-days* [2]	*Cow-acre-days* [2]
2. 0	4. 0	6	11	35	55	40	65	30	40	100	190	10	11	3	6
2. 3	4. 2	7	13	42	65	47	75	35	46	130	250	11	12	3. 5	7
2. 0	4. 0	6	12	37	60	40	65	30	40	110	220	10	11	3	6
1. 8	3. 7	5	10	30	50	35	60	25	35	90	180	9	10	3	6
2. 5	4. 5	8	14	45	70	50	80	38	50	130	250	11	12	3. 5	7
2. 3	4. 2	7	13	42	65	47	75	35	46	120	230	11	12	3. 5	7
2. 3	4. 2	7	13	42	65	47	75	35	46	130	250	11	12	3. 5	7
2. 0	4. 0	6	12	37	60	40	65	30	40	110	220	10	11	3	6
------	------	------	------	------	------	------	------	------	------	110	200	------	------	3	6
------	------	------	------	------	------	------	------	------	------	100	190	------	------	3	6
------	------	------	------	------	------	------	------	------	------	80	140	------	------	2. 5	5
2. 0	3. 8	6	11	27	46	32	55	22	30	95	190	7	8	3	6
1. 9	3. 7	5	11	24	45	30	55	20	30	90	190	7	8	2. 5	5
2. 5	4. 5	7	13	35	60	40	70	30	40	115	230	10	11	3	6
2. 3	4. 2	6	12	30	50	35	60	25	35	105	210	10	11	3	6
2. 0	4. 0	5	10	25	42	30	50	20	30	90	180	9	10	2. 5	5
2. 5	4. 5	7	13	37	62	42	72	30	40	125	250	10	11	3	6
2. 3	4. 2	6	12	32	52	37	62	25	35	115	220	10	11	3	6
2. 1	4. 2	5	11	25	45	30	55	20	30	100	200	10	11	3	6
2. 3	4. 2	6	12	30	50	35	60	25	35	110	230	10	11	3	6
2. 0	4. 0	5	11	25	45	30	55	20	30	90	180	9	10	2. 5	5
1. 8	3. 7	4	8	20	38	25	45	15	25	80	160	9	10	2. 5	5
2. 5	4. 5	7	13	35	60	40	70	30	40	120	230	10	11	3	6
2. 3	4. 2	6	12	30	50	35	60	25	35	105	210	10	11	3	6
2. 0	4. 0	5	10	25	42	30	50	20	30	90	180	9	10	2. 5	5
------	------	------	------	------	------	------	------	------	------	70	140	8	9	2. 5	5
2. 3	4. 2	6	12	30	55	35	65	25	35	110	220	10	11	3	6
2. 0	4. 0	5	10	25	45	30	50	20	30	100	200	10	11	3	6
1. 8	3. 7	4	8	20	38	25	45	15	25	90	180	9	10	2. 5	5
------	------	------	------	------	------	------	------	------	------	60	130	8	9	2. 5	5
1. 0	2. 0	4	7	20	35	25	40	15	25	70	140	6	7	2	4
1. 0	2. 0	3	6	17	30	23	35	12	20	60	120	6	7	2	4
------	------	------	------	------	------	------	------	------	------	40	80	4	5	1. 5	3
1. 0	2. 0	3	6	15	28	21	32	10	18	50	120	6	7	2	4
------	------	------	------	------	------	------	------	------	------	40	100	5	6	2	4
------	------	------	------	------	------	------	------	------	------	100	200	------	------	3	6
------	------	------	------	------	------	------	------	------	------	90	180	------	------	3	6
------	------	------	------	------	------	------	------	------	------	70	150	------	------	2. 5	5
------	------	------	------	------	------	------	------	------	------	------	------	------	------	2. 5	5
2. 5	4. 5	8	14	37	62	42	72	30	40	125	250	9	10	3	6
2. 3	4. 2	7	12	32	52	37	62	25	35	110	215	9	10	3	6
2. 0	4. 0	6	11	25	45	30	55	20	30	90	170	8	9	3	6
2. 4	4. 4	8	14	35	60	40	70	28	38	120	240	9	10	3	6
2. 0	4. 0	6	11	25	45	30	55	20	30	90	190	8	9	3	6
2. 4	4. 4	8	14	37	62	42	72	30	40	125	250	9	10	3	6
2. 3	4. 2	7	12	32	52	37	62	25	35	110	215	9	10	3	6
1. 8	3. 0	6	12	30	55	40	70	25	35	150	260	10	11	6	10
1. 8	3. 0	6	12	30	55	40	70	25	35	120	230	10	11	6	10
1. 8	3. 0	6	12	30	55	40	70	25	35	140	250	9	10	6	10
2. 0	3. 5	8	14	45	70	50	80	38	50	130	250	10	11	4	7
2. 0	3. 5	8	14	40	65	45	75	33	43	125	240	9	10	3. 5	7
2. 0	3. 5	7	13	35	60	40	70	28	38	120	230	8	9	3	6
1. 8	3. 2	6	11	30	50	35	60	23	30	105	210	8	9	3	6
2. 0	3. 5	7	13	35	60	40	70	28	38	125	240	9	10	3	6
------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
------	------	------	------	------	------	------	------	------	------	------	------	------	------	2	3. 5
------	------	------	------	------	------	------	------	------	------	------	------	------	------	2	3. 5
------	------	------	------	------	------	------	------	------	------	30	50	------	------	1	2
------	------	------	------	------	------	------	------	------	------	------	------	------	------	1	2
1. 1	2. 0	3	6	15	25	20	35	12	20	60	120	------	------	2	3. 5

In the Deschutes Area, the grazing season is considered to be 150 days for irrigated pasture and 135 days for range.

[3] This soil will be irrigated when the facilities of the Deschutes Irrigation Project are finished.

[4] Slightly higher yields are obtained in the areas near Haystack Butte.

The Capability Classification

The capability classification is a means of showing the relative suitability of different soils for agricultural uses. The classification of a particular soil depends on the variety of uses to which it is suited, its susceptibility to erosion or other damage when it is used, and the kind of management it needs to protect it from erosion and to maintain its productivity.

Capability classes.—Eight general capability classes are recognized. In classes I, II, and III are soils that are suitable for annual or periodic cultivation. Class I soils are those that have the widest range of use and the least risk of damage. They are level or nearly level, productive, well drained, and easy to work. They can be cultivated continuously with practically no risk of erosion and will remain productive if managed with normal care.

Class II soils can be cultivated regularly but do not have quite so wide a range of suitability as class I soils. Some class II soils are gently sloping and consequently need moderate care to prevent erosion; others may be slightly droughty or slightly wet, or somewhat limited in depth.

Class III soils can be cropped regularly but have a narrower range of use and need still more careful management.

In class IV are soils that should be cultivated only occasionally or only under very careful management.

In classes V, VI, and VII are soils that should not be cultivated but that can be used for pasture, for range, or for forest. Class V soils are level but are droughty, wet, low in fertility, or otherwise unsuitable for cultivation. None of the soils in the Deschutes Area are in class V.

Class VI soils are not suitable for crops because they are steep or droughty or otherwise limited, but they give fair yields of forage or forest products. Some soils in class VI can, without damage, be cultivated enough so that fruit trees or forest trees can be set out or pasture plants seeded.

Class VII soils provide only poor to fair yields of forage or forest products.

In class VIII are soils that have practically no agricultural use. They produce little useful vegetation, but they may constitute attractive scenery; they may form parts of watersheds; or they may provide shelter for wildlife. Some areas have been developed as recreational sites. Mountains, deserts, and sand dunes are examples of class VIII land.

Capability subclasses.—The soils in any one capability class are limited to the same degree, but they may be limited for different reasons. To show the main kind of limiting factor, any one of classes II through VIII may be divided into subclasses, each identified by a letter following the capability class number. The letter "e" indicates that the risk of erosion is what limits the uses of the soil the letter "w" is used if the soil is too wet for general use. the letter "s" shows that the soil is shallow, droughty, or unusually low in fertility; and the letter "c" is used to indicate that the climate is so hazardous that it limits the uses of the soil.

Capability Classes and Subclasses in the Deschutes Area

In the following outline, the capability classes and subclasses in the Deschutes Area are defined. For each subclass, a brief description of the general nature of the dominant soils is given.

Class I.—Deep, nearly level, productive soils, suitable for intensive cultivation without special practices other than those normally used in the Area for good farming.

Class II.—Soils suitable for tilled crops, pasture, and trees. These soils have moderate limitations if used for tilled crops.

Subclass IIs: Level and nearly level loamy soils that have slightly limited moisture-supplying capacity. Some are eroded.

Subclass IIw: Level and nearly level clay loam and sandy loam soils that are too wet during a part of each growing season.

Class III.—Soils suitable for tilled crops, pasture, and trees. These soils have moderately severe limitations if used for tilled crops.

Subclass IIIe: Gently sloping soils subject to erosion.

Subclass IIIs: Nearly level, sandy or stony, droughty soils.

Class IV.—Soils suitable for grass and trees. These soils are severely limited if used for tilled crops.

Subclass IVe: Moderately sloping and gently sloping soils subject to erosion.

Subclass IVs: Loamy and sandy, shallow, droughty soils.

Class VI.—Soils suitable for pasture or trees. These soils ordinarily are not suitable for tilled crops because they are steep, wet, shallow, or otherwise limited.

Subclass VIe: Strongly sloping and moderately sloping soils that are extremely erodible if tilled.

Class VII.—Soils not suitable for cultivation and of severely limited use for pasture or as woodland.

Subclass VIIe: Scabland and strongly sloping to steep Rough broken land and Rough stony land.

Class VIII.—Soils not suitable for growing vegetation for commercial use.

The capability class and subclass for each soil in the Deschutes Area are given in the following list:

	Capability class and subclass
Agency gravelly loam, 0 to 3 percent slopes (Aa)	IIs
Agency gravelly loam, 3 to 7 percent slopes (Ab)	IIIe
Agency gravelly loam, 7 to 12 percent slopes (Ad)	IVe
Agency gravelly loam, eroded, 3 to 7 percent slopes (Ac)	IIIe
Agency gravelly loam, eroded, 7 to 12 percent slopes (Ae)	IVe
Agency loam, 0 to 3 percent slopes (Af)	IIs
Agency loam, 3 to 7 percent slopes (Ah)	IIIe
Agency loam, 7 to 12 percent slopes (Al)	IVe
Agency loam, 12 to 20 percent slopes (Am)	VIe
Agency loam, eroded, 0 to 3 percent slopes (Ag)	IIs
Agency loam, eroded, 3 to 7 percent slopes (Ak)	IIIe
Agency loam, eroded, 20 to 35 percent slopes (An)	VIe
Agency loam, stony, 0 to 3 percent slopes (Ao)	VIs
Agency loam, stony, 3 to 7 percent slopes (Ap)	VIs
Agency loam, stony, 7 to 12 percent slopes (Ar)	VIs
Agency loam, stony, 12 to 20 percent slopes (As)	VIe
Agency loam, stony, 20 to 35 percent slopes (At)	VIe

	Capability class and subclass
Agency sandy loam, 0 to 3 percent slopes (Au)	IIs
Agency sandy loam, 3 to 7 percent slopes (Aw)	IIIe
Agency sandy loam, eroded, 0 to 3 percent slopes (Av)	IIs
Agency sandy loam, eroded, 3 to 7 percent slopes (Ax)	IIIe
Deschutes coarse sandy loam, over sandy material, 0 to 3 percent slopes (Da)	IVs
Deschutes loam, stony, 0 to 3 percent slopes (Db)	IIIs
Deschutes loamy coarse sand, over gravelly material, 0 to 3 percent slopes (Dc)	IIs
Deschutes loamy coarse sand, over gravelly material, 3 to 7 percent slopes (Dd)	IIIe
Deschutes loamy sand, 0 to 3 percent slopes (De)	IIIs
Deschutes loamy sand, 3 to 7 percent slopes (Dg)	IVe
Deschutes loamy sand, 7 to 12 percent slopes (Dh)	VIe
Deschutes loamy sand, eroded, 0 to 3 percent slopes (Df)	IIIs
Deschutes loamy sand, over cinders, 0 to 3 percent slopes (Dk)	IIIs
Deschutes loamy sand, over cinders, 3 to 7 percent slopes (Dl)	IVe
Deschutes loamy sand, over cinders, eroded, 3 to 7 percent slopes (Dm)	IVe
Deschutes loamy sand, over cobbly material, 0 to 3 percent slopes (Dn)	IVs
Deschutes loamy sand, over gravelly material, 0 to 3 percent slopes (Do)	IIs
Deschutes loamy sand, over gravelly material, 3 to 7 percent slopes (Dp)	IIIe
Deschutes loamy sand, over semicemented sandy material, 0 to 3 percent slopes (Dr)	IIIs
Deschutes loamy sand, over semicemented sandy material, 3 to 7 percent slopes (Ds)	IVe
Deschutes loamy sand, over semicemented sandy material, 7 to 12 percent slopes (Dt)	VIe
Deschutes sandy loam, 0 to 3 percent slopes (Du)	IIs
Deschutes sandy loam, 3 to 7 percent slopes (Dv)	IIIe
Deschutes sandy loam, 7 to 12 percent slopes (Dw)	IVe
Deschutes sandy loam, 12 to 20 percent slopes (Dy)	VIe
Deschutes sandy loam, deep, 0 to 3 percent slopes (Dz)	I
Deschutes sandy loam, deep, 3 to 7 percent slopes (Dea)	IIIe
Deschutes sandy loam, deep over cinders, 0 to 3 percent clopes (Deb)	IIs
Deschutes sandy loam, eroded, 7 to 12 percent slopes (Dx)	IVe
Deschutes sandy loam, over cinders, 0 to 3 percent slopes (Dec)	IIs
Deschutes sandy loam, over cinders, 3 to 7 percent slopes (Ded)	IIIe
Deschutes sandy loam, over cinders, eroded, 3 to 7 percent slopes (Del)	IIIe
Deschutes sandy loam, over semicemented sandy material, 0 to 3 percent slopes (Deo)	IIs
Deschutes sandy loam, over semicemented sandy material, 3 to 7 percent slopes (Des)	IIIe
Deschutes sandy loam, over semicemented sandy material, 7 to 12 percent slopes (Dla)	IVe
Deschutes sandy loam, over semicemented sandy material, eroded, 12 to 20 percent slopes (Dlb)	VIe
Deschutes sandy loam, shallow, 0 to 3 percent slopes (Dlc)	IVs
Deschutes sandy loam, shallow, 3 to 7 percent slopes (Dle)	IVe
Deschutes sandy loam, shallow over cinders, 0 to 3 percent slopes (Dlo)	IVs
Deschutes sandy loam, shallow over cinders, eroded, 3 to 7 percent slopes (Dls)	IVe
Deschutes sandy loam, stony, 0 to 3 percent slopes (Dsa)	IIIs
Deschutes sandy loam, stony, 3 to 7 percent slopes (Dsb)	IIIe
Deschutes sandy loam, stony, 7 to 12 percent slopes (Dsc)	IVe
Deschutes sandy loam, stony, over cinders, 3 to 7 percent slopes (Dsd)	IIIe
Deschutes sandy loam, stony, over semicemented sandy material, 0 to 3 percent slopes (Dse)	IIIs
Deschutes sandy loam, stony, over semicemented sandy material, 3 to 7 percent slopes (Dsl)	IIIe
Deschutes sandy loam, stony, over semicemented sandy material, 7 to 12 percent slopes (Dso)	IVe
Era sandy loam, 0 to 3 percent slopes (Ea)	IIs
Era sandy loam, 3 to 7 percent slopes (Ec)	IIIe
Era sandy loam, 7 to 12 percent slopes (Ee)	IVe
Era sandy loam, 12 to 20 percent slopes (Eg)	VIe
Era sandy loam, eroded, 0 to 3 percent slopes (Eb)	IIs
Era sandy loam, eroded, 3 to 7 percent slopes (Ed)	IIIe
Era sandy loam, eroded, 7 to 12 percent slopes (Ef)	IVe
Era sandy loam, eroded, 12 to 20 percent slopes (Eh)	VIe
Gem clay loam, eroded, 3 to 12 percent slopes (Ga)	IIIe or IVe[4]
Gem clay loam, eroded, 12 to 20 percent slopes (Gb)	VIe
Gem clay loam, shallow, 7 to 12 percent slopes (Gc)	IVe
Gem clay loam, shallow, eroded, 7 to 12 percent slopes (Gd)	IVe
Gem loam, 3 to 7 percent slopes (Ge)	IIIe
Gem loam, 7 to 12 percent slopes (Go)	IVe
Gem loam, eroded, 7 to 12 percent slopes (Gs)	IVe
Laidlaw sandy loam, 0 to 3 percent slopes (La)	IIIs
Laidlaw sandy loam, 3 to 7 percent slopes (Lb)	IVe
Laidlaw sandy loam, 7 to 12 percent slopes (Lc)	VIe
Laidlaw sandy loam, eroded, 7 to 12 percent slopes (Ld)	VIe
Laidlaw sandy loam, eroded, 12 to 20 percent slopes (Le)	VIe
Lamonta loam, 0 to 3 percent slopes (Lf)	IIs
Lamonta loam, 3 to 7 percent slopes (Lh)	IIIe
Lamonta loam, 7 to 12 percent slopes (Lm)	IVe
Lamonta loam, 12 to 20 percent slopes (Lo)	VIe
Lamonta loam, eroded, 0 to 3 percent slopes (Lg)	IIs
Lamonta loam, eroded, 3 to 7 percent slopes (Lk)	IIIe
Lamonta loam, eroded, 7 to 12 percent slopes (Ln)	IVe
Lamonta loam, eroded, 12 to 20 percent slopes (Lp)	VIe
Lamonta loam, shallow, 0 to 3 percent slopes (Lr)	IVs
Lamonta loam, shallow, 3 to 7 percent slopes (Ls)	IVe
Lamonta loam, shallow, eroded, 3 to 7 percent slopes (Lt)	IVe
Lamonta loam, shallow, eroded, 7 to 12 percent slopes (Lu)	IVe
Lamonta loam, stony, 0 to 3 percent slopes (Lv)	VIs
Lamonta loam, stony, 3 to 7 percent slopes (Lw)	VIs
Lamonta loam, stony, 7 to 12 percent slopes (Lx)	IVe
Lamonta sandy clay loam, 0 to 3 percent slopes (Ly)	IIs
Lamonta sandy clay loam, 3 to 7 percent slopes (Lea)	IIIe
Lamonta sandy clay loam, 7 to 12 percent slopes (Led)	IVe
Lamonta sandy clay loam, eroded, 0 to 3 percent slopes (Lz)	IIs
Lamonta sandy clay loam, eroded, 3 to 7 percent slopes (Lec)	IIIe
Lamonta sandy clay loam, eroded, 7 to 12 percent slopes (Leh)	IVe
Lamonta sandy clay loam, eroded, 12 to 20 percent slopes (Ler)	VIe
Lamonta sandy clay loam, shallow, 0 to 3 percent slopes (Lev)	IVs
Lamonta sandy clay loam, shallow, 3 to 7 percent slopes (Lsa)	IVe
Lamonta sandy clay loam, shallow, eroded, 3 to 7 percent slopes (Lsb)	IVe
Lamonta sandy clay loam, shallow, eroded, 7 to 12 percent slopes (Lsc)	IVe
Lamonta sandy clay loam, stony, 0 to 3 percent slopes (Lsd)	VIs
Lamonta sandy clay loam, stony, 3 to 7 percent slopes (Lse)	VIs
Lamonta sandy clay loam, stony, 7 to 12 percent slopes (Lsl)	VIs

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[4] Gem clay loam, eroded, 3 to 12 percent slopes, has two capability classifications. The soil with a slope range of 3 to 7 percent is classified IIIe; that with a slope range of 7 to 12 percent is classified IVe.

	Capability class and subclass
Lamonta sandy clay loam, stony, 12 to 20 percent slopes (Lso)	VIe
Madras loam, 0 to 3 percent slopes (Ma)	IIs
Madras loam, 3 to 7 percent slopes (Mc)	IIIe
Madras loam, 7 to 12 percent slopes (Me)	IVe
Madras loam, eroded, 0 to 3 percent slopes (Mb)	IIs
Madras loam, eroded, 3 to 7 percent slopes (Md)	IIIe
Madras loam, eroded, 7 to 12 percent slopes (Mf)	IVe
Madras loam, over sandstone, 0 to 3 percent slopes (Mg)	IIs
Madras loam, over sandstone, 3 to 7 percent slopes (Mk)	IIIe
Madras loam, over sandstone, eroded, 0 to 3 percent slopes (Mh)	IIs
Madras loam, over sandstone, eroded, 3 to 7 percent slopes (Ml)	IIIe
Madras loam, stony, 0 to 3 percent slopes (Mm)	VIs
Madras loam, stony, 3 to 7 percent slopes (Mn)	VIs
Madras loam, stony, 7 to 12 percent slopes (Mo)	VIs
Madras loamy sand, over sandstone, 3 to 7 percent slopes (Mp)	IVe
Madras loamy sand, over sandstone, eroded, 3 to 7 percent slopes (Mr)	IVe
Madras sandy loam, 0 to 3 percent slopes (Ms)	IIs
Madras sandy loam, 3 to 7 percent slopes (Mu)	IIIe
Madras sandy loam, 7 to 12 percent slopes (My)	IVe
Madras sandy loam, deep over sandstone, 0 to 3 percent slopes (Mea)	I
Madras sandy loam, deep over sandstone, 3 to 7 percent slopes (Meb)	IIIe
Madras sandy loam, deep over sandstone, eroded, 3 to 7 percent slopes (Mec)	IIIe
Madras sandy loam, eroded, 0 to 3 percent slopes (Mt)	IIs
Madras sandy loam, eroded, 3 to 7 percent slopes (Mv)	IIIe
Madras sandy loam, eroded, 7 to 12 percent slopes (Mz)	IVe
Madras sandy loam, over sandstone, 0 to 3 percent slopes (Med)	IIs
Madras sandy loam, over sandstone, 3 to 7 percent slopes (Meh)	IIIe
Madras sandy loam, over sandstone, 7 to 12 percent slopes (Meo)	IVe
Madras sandy loam, over sandstone, 12 to 20 percent slopes (Mla)	VIe
Madras sandy loam, over sandstone, eroded, 0 to 3 percent slopes (Mef)	IIs
Madras sandy loam, over sandstone, eroded, 3 to 7 percent slopes (Mel)	IIIe
Madras sandy loam, over sandstone, eroded, 7 to 12 percent slopes (Mes)	IVe
Madras sandy loam, over sandstone, eroded, 12 to 20 percent slopes (Mlc)	VIe
Madras sandy loam, shallow over sandstone, 0 to 3 percent slopes (Mld)	IVs
Madras sandy loam, shallow over sandstone, 3 to 7 percent slopes (Mle)	IVe
Madras sandy loam, shallow over sandstone, 12 to 20 percent slopes (Moc)	VIe
Madras sandy loam, shallow over sandstone, eroded, 3 to 7 percent slopes (Mlo)	IVe
Madras sandy loam, shallow over sandstone, eroded, 7 to 12 percent slopes (Mls)	IVe
Madras sandy loam, stony, over sandstone, 0 to 3 percent slopes (Mod)	VIs
Madras sandy loam, stony, over sandstone, 3 to 7 percent slopes (Moe)	VIs
Madras sandy loam stony, over sandstone, 7 to 12 percent slopes (Mol)	VIs
Madras sandy loam, stony, over sandstone, 12 to 20 percent slopes (Mos)	VIe
Metolius sandy loam, 0 to 3 percent slopes (Mta)	I
Metolius sandy loam, 3 to 7 percent slopes (Mtd)	IIIe
Metolius sandy loam, 7 to 12 percent slopes (Mts)	IVe
Metolius sandy loam, eroded, 0 to 3 percent slopes (Mtc)	I
Metolius sandy loam, eroded, 3 to 7 percent slopes (Mte)	IIIe
Metolius sandy loam, terrace position, 0 to 3 percent slopes (Mtl)	IIs
Metolius sandy loam, terrace position, 3 to 7 percent slopes (Mto)	IIIe
Odin clay loam, 0 to 3 percent slopes (Oa)	IIw
Odin clay loam, 3 to 7 percent slopes (Ob)	IIIw
Odin sandy loam, 0 to 3 percent slopes (Oc)	IIw
Redmond clay loam, 0 to 3 percent slopes (Ra)	IIs
Redmond loam, 0 to 3 percent slopes (Rb)	IIs
Redmond sandy loam, 0 to 3 percent slopes (Rc)	IIs
Redmond sandy loam, 3 to 7 percent slopes (Rd)	IIIe
Redmond sandy loam, deep, 0 to 3 percent slopes (Re)	IIs
Riverwash (Rk)	VIII
Rough broken land, Era and Deschutes soil materials, 12 to 50 percent slopes (Ro)	VIIe
Rough stony land, Agency and Deschutes soil materials, 12 to 60 percent slopes (Rs)	VIIe
Scabland, 0 to 3 percent slopes (Sa)	VIIe
Scabland, 3 to 12 percent slopes (Sb)	VIIe
Volcanic ash, 0 to 3 percent slopes, (Vo)	IVs

General Nature of the Deschutes Area

The Deschutes Area consists of 336,795 acres, or 526.2 square miles, in west-central Oregon. The Area begins a few miles east of the Cascade Mountains. It extends from about 3 miles south of Bend, in Deschutes County, almost to the northern boundary of Jefferson County. Its area is about equally divided between these two counties. Irregularly shaped, the Area is 57 miles long from north to south, and 7 to 15 miles wide.

Bend, the largest town in the Area and the county seat of Deschutes County, is about 180 miles by highway southeast of Portland. Madras, the county seat of Jefferson County, is 45 miles north of Bend.

Physiography and Drainage

The Deschutes Area is in the southwestern part of the Walla Walla section of the Columbia Plateau physiographic province (*4*). It consists principally of a nearly level to rolling high plain, or plateau, which slopes very gently northward. The altitude is about 3,700 feet south of Bend; 3,000 feet near Redmond; 2,850 feet near Opal City; 2,650 feet near Culver; and 2,300 to 2,500 feet on the Agency Plains.

A number of buttes rise 100 to 1,600 feet above the plain. Some, including Tetherow Butte, Round Butte, and Pilot Butte, are volcanic peaks. Apparently they were the sources of some of the lava flows and cinder deposits in the Area. Pilot Butte is 4,136 feet above sea level.

The range in altitude within the surveyed Area is 3,130 feet. The highest point is southeast of Opal City, at the summit of an unnamed butte that rises to an altitude of 4,420 feet. This butte is a secondary peak connected with Gray Butte (altitude 5,108 feet), which is in the southern part of Jefferson County, outside the surveyed Area. Gray Butte, Haystack Butte, and Juniper Butte and the surrounding higher region east of Opal City are eroded remnants of the southwestern part of the Hay Creek uplift, which extends northeastward toward the Blue Mountains (*5*). The lowest point in the Area—about 1,290 feet—is where the Deschutes River crosses the northern boundary.

The Area is drained by the Deschutes River and its tributaries. The main tributaries are the Crooked River, Mud Spring Creek, and Willow Creek. The Deschutes River enters the Area from the south at an altitude of about 3,700 feet. It flows in a shallow valley only 50 to 100 feet lower than the adjoining plain to the east. The valley becomes only slightly deeper as the river flows northward to Big Falls. Below Big Falls, the river has cut deeper, and it flows across most of Jefferson County in a narrow V-shaped canyon 700 to 1,000 feet below the plain. It crosses the northern boundary of the Area at an altitude of about 1,290 feet.

The Crooked River enters the Area from the east at an altitude of about 2,760 feet. Like the Deschutes River, it flows first in a shallow valley only slightly lower than the plain to the south; but farther north, it has cut a narrow box canyon. The Crooked River flows into the Deschutes River at an altitude of about 1,610 feet. Only very small areas of bottom land occur along these rivers.

Much of the Area has a constructional topography in which streams have caused little or no dissection. This is particularly noticeable in areas underlain by lava flows and in areas west of the Deschutes River that are underlain by outwash sand and gravel. Most of the southeastern part of the Area was covered by the most recent lava flow. This region is undulating or somewhat rolling. The higher parts of the uneven surface are narrow ridges, mounds, or swells of outcropping lava, or shallow very stony soils. Between the higher parts are swales, disconnected shallow basins, and level areas where the soils are deeper and arable. Many of the swales and basins have no surface drainage outlets.

Climate

The climate of the Deschutes Area is continental, but the moderating effects of the Pacific Ocean are not entirely shut off by the Cascade Mountains. The prevailing weather is not so mild as that of western Oregon nor so rigorous as that of the Rocky Mountain region or the Great Plains.

The Area has light precipitation. Summers are dry, with warm days and cool nights. Winters are cold, with moderate snowfall. The climate is healthful and invigorating, and there is a high percentage of sunshine. Because the frost-free season is short in much of the Area, hay, grain, potatoes, legumes for seed, or other hardy or short-season crops are grown.

Table 4 gives the climatic data for four United States Weather Bureau Stations in or near the Area. The data for most of these places are representative of the climate of the respective localities, but the data for Madras is not representative of the climate of the region around Madras. Madras lies in a low, wide pocket in the valley of Willow Creek, about 300 feet below the surrounding plains. It probably has slightly less precipitation and a warmer summer than the surrounding plains, and its growing season is shorter.

Most of the Deschutes Area is semiarid, but the extreme southern and western parts are subhumid. The normal annual precipitation of the semiarid region is about 8 to 10 inches. The precipitation increases as altitude increases, or generally in the direction of the top of the Cascade Mountains. Most of the moisture in the prevailing westerly winds falls on the western side of the Cascades; consequently, the lower areas on the leeward side of the mountains are relatively dry. Warm Springs, which is nearer the Cascade Mountains than Madras, receives more than 1 inch more precipitation than Madras, even though it lies in a valley 700 feet lower than Madras.

As the westerly winds move eastward over the Hay Creek uplift (*9*) and Ochoco Mountains, precipitation increases. At Hay Creek, which is about 9 miles east of Madras and at an altitude of 2,938 feet, the average annual precipitation is 11.75 inches, almost 3 inches higher than at Madras; the snowfall is 6.3 inches higher. At Juniper Butte (3,935 ft.), Haystack Butte (4,023 ft.), and the higher adjoining area east of Opal City, precipitation is a few inches more than on the low-lying plain around Madras and Redmond.

From Redmond westward and southwestward toward the Cascades, the precipitation increases. The highest precipitation in the Area apparently is in the extreme southern part, south of Bend; in the extreme western part near Cloverdale; and in places along the southwestern boundary between these areas. In these regions the normal annual precipitation probably is about 13 to 15 inches.

The annual rainfall varies greatly from year to year. At Bend it has varied from 6.04 to 25.74 inches and at Redmond, from 4.39 to 14.19 inches. The precipitation is distributed unevenly throughout the year, but it is

TABLE 4.—*Temperature and precipitation at four weather stations*

BEND, ELEVATION 3,599 FEET

Month	Temperature [1]			Precipitation [2]			
	Average	Absolute maximum	Absolute minimum	Average	Driest year	Wettest year	Average snowfall
	° *F.*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	31. 9	69	−25	1. 70	0. 42	4. 78	9. 1
January	30. 4	66	−26	1. 70	. 35	6. 34	11. 0
February	34. 2	76	−26	1. 51	1. 20	4. 00	7. 0
Winter	32. 2	76	−26	4. 91	1. 97	15. 12	27. 1
March	38. 9	83	−13	1. 10	1. 11	2. 33	4. 1
April	44. 6	90	8	. 79	. 07	1. 30	1. 0
May	50. 8	90	11	1. 14	. 60	1. 42	. 3
Spring	44. 8	90	−13	3. 03	1. 78	5. 05	5. 4
June	58. 6	100	22	1. 00	. 21	1. 79	(3)
July	65. 0	104	28	. 50	(3)	. 23	0
August	63. 3	100	25	. 31	. 07	1. 44	(3)
Summer	62. 3	104	22	1. 81	. 28	3. 46	(3)
September	55. 5	97	12	. 64	. 26	. 96	(3)
October	48. 0	91	10	. 68	. 15	. 40	. 4
November	39. 1	77	−5	1. 65	1. 60	. 76	3. 0
Fall	47. 5	97	−5	2. 97	2. 01	2. 12	3. 4
Year	46. 7	104	−26	12. 72	[4] 6. 04	[5] 25. 75	35. 9

See footnotes at end of table.

TABLE 4.—*Temperature and precipitation at four weather stations*—Continued

HAY CREEK, ELEVATION 3,599 FEET

Month	Temperature [1]			Precipitation [2]			
	Average	Absolute maximum	Absolute minimum	Average	Driest year	Wettest year	Average snowfall
	° F.	° F.	° F.	*Inches*	*Inches*	*Inches*	*Inches*
December	33.4	72	−28	1.30	1.78	1.41	6.2
January	30.9	66	−25	1.43	.30	2.46	8.8
February	35.2	72	−22	.98	.55	1.27	3.9
Winter	33.2	72	−28	3.71	2.63	5.14	18.9
March	40.7	85	−2	.90	.58	1.13	1.7
April	45.9	87	12	.78	.04	2.02	1.2
May	52.0	92	19	1.49	(3)	2.98	.2
Spring	46.2	92	−2	3.17	.62	6.13	3.1
June	58.0	98	28	.81	.04	2.04	0
July	65.3	110	31	.51	0	.38	0
August	63.4	101	29	.31	(3)	.78	0
Summer	62.2	110	28	1.63	.04	3.20	0
September	56.2	97	15	.84	(3)	.79	.1
October	48.1	87	6	.74	.48	.94	.3
November	38.7	73	−7	1.66	1.31	1.32	1.2
Fall	47.6	97	−7	3.24	1.79	3.05	1.6
Year	47.3	110	−28	11.75	[6] 5.08	[7] 17.52	23.6

MADRAS, ELEVATION 2,994 FEET

December	31.5	66	−45	1.10	0.17	1.80	4.4
January	29.7	70	−40	1.09	.20	1.34	7.4
February	34.6	76	−34	.69	.19	1.28	2.7
Winter	31.9	76	−45	2.28	.56	4.42	14.5
March	40.9	81	−7	.64	.92	1.32	1.4
April	46.2	93	6	.63	.07	1.24	.2
May	52.6	98	12	.86	.43	2.30	(3)
Spring	46.6	98	−7	2.13	1.42	4.86	1.6
June	59.5	105	21	.70	0	2.21	(3)
July	66.5	112	26	.20	(3)	.43	0
August	64.2	105	26	.28	0	.56	0
Summer	63.4	112	21	1.18	(3)	3.20	(3)
September	56.8	101	9	.66	.05	1.33	(3)
October	48.0	88	0	.65	.29	.16	.1
November	38.2	80	−12	1.30	1.81	1.27	1.1
Fall	47.7	101	−12	2.61	2.15	2.76	1.2
Year	**47.4**	112	−45	8.80	[4] 4.13	[8] 15.24	17.3

TABLE 4.—*Temperature and precipitation at four weather stations*—Continued

REDMOND, ELEVATION 2,994 FEET

Month	Temperature [1]			Precipitation [2]			
	Average	Absolute maximum	Absolute minimum	Average	Driest year	Wettest year	Average snowfall
	° F.	° F.	° F.	*Inches*	*Inches*	*Inches*	*Inches*
December	34.0	72	−19	0.86	0.40	2.38	3.5
January	32.0	66	−24	1.01	.44	.93	7.5
February	36.2	72	−24	.65	.44	1.43	3.4
Winter	34.1	72	−24	2.52	1.28	4.74	14.4
March	41.8	82	9	.56	1.31	.64	.9
April	47.8	86	14	.70	.18	.78	.7
May	52.9	95	21	.75	.63	2.38	(3)
Spring	47.5	95	9	2.01	2.12	3.80	1.6
June	58.6	100	26	1.02	.02	1.68	(3)
July	65.8	105	31	.48	0	.60	0
August	64.3	98	29	.22	(3)	.79	0
Summer	62.9	105	26	1.72	.02	3.07	(3)
September	57.4	97	22	.45	.18	1.27	(3)
October	49.1	93	9	.57	.08	.16	.3
November	39.5	74	−5	.87	.71	1.15	.7
Fall	48.7	97	−5	1.89	.97	2.58	1.0
Year	48.3	105	−24	8.14	[4] 4.39	[8] 4.19	17.0

[1] Bend: Average temperature based on a 49-year record, 1907–55; highest and lowest temperatures from a 47-year record, 1906–52. Hay Creek: Average temperature based on a 28-year record, 1916–43; highest and lowest temperatures from a 24-year record, 1929–52. Madras: Average temperature based on a 34-year record, 1922–55; highest and lowest temperature from a 35-year record, 1918–52. Redmond: Average temperature based on a 25-year record, 1931–55; highest and lowest temperature from a 22-year record, 1931–52.

[2] Bend: Average precipitation based on a 51-year record, 1905–55; wettest and driest years based on a 53-year record, in the period 1902–55; snowfall based on a 48-year record, 1905–52. Hay Creek: Average precipitation based on a 28-year record, 1916–43; wettest and driest years based on a 26-year record, in the period 1910–44; snowfall based on a 29-year record, 1924–52. Madras: Average precipitation based on a 35-year record, 1921–55; wettest and driest year based on a 39-year record, 1909–55; snowfall based on a 35-year record, 1918–52. Redmond: Average precipitation based on a 24-year record, 1932–55; wettest and driest years based on a 19-year record, in the period 1931–52; snowfall based on a 40-year record, 1913–52.

[3] Trace or no record.

[4] In 1949.

[5] In 1907.

[6] In 1924.

[7] In 1912.

[8] In 1948.

distributed more evenly than that west of the Cascade Mountains. The precipitation is greatest in winter, when a large part falls as snow. Generally, May and June are months of relatively high rainfall; August and July commonly are the driest months. Most of the rains are light, but thunderstorms are somewhat frequent in summer. The average snowfall varies from 17.0 inches at Redmond to 35.9 inches at Bend.

The extremes in temperature are wide. A temperature of 45° F. below zero was recorded at Madras. Although temperatures rise above 100°, the humidity is low in summer, and nights are cool. The coldest weather in winter and the warmest in summer occur when the ocean winds cease and the Area is dominated by a mass of continental air.

The average growing season is 88 days at Bend, 101 days at Madras, and 123 days at Hay Creek. The length of growing season, however, varies from year to year. Frost has occurred at Bend as late as July 29 and as early as August 14. At Madras it has occurred as late as June 17 and as early as August 24.

In some of the high areas near the Cascade Mountains and in some low pockets, freezing temperatures may occur every month. At the Madras station, which is in a low pocketlike valley, freezing temperatures occurred every month in 7 of the years from 1909 to 1930. These low temperatures, however, are not typical of the surrounding higher plains. Successful crop production in areas of low temperature is largely limited to grasses, legumes, small grains, and the more hardy crops.

In most of the Area, late spring frost occasionally injures potatoes, corn, and garden vegetables; less frequently, frost damages wheat or grain. Potatoes, corn, and less hardy crops generally are not planted until the danger of frost is largely past. The growing season normally is too short for winter cover crops to follow the potato harvest.

Hail and glaze-ice storms occasionally occur but seldom do material damage. Tornadoes are very rare. Winds are variable. On the Agency Plains, northwesterly winds generally dominate, although southwesterly winds prevail in winter. Here, they sometimes cause wind erosion. At Madras, the prevailing winds are southwesterly in winter and northwesterly in summer. At Bend, westerly winds prevail.

Vegetation and Wildlife

In a considerable part of the Deschutes Area, the natural vegetation is dominated by big sagebrush (*Artemisia tridentata*), bunchgrasses, and western juniper (*Juniperus occidentalis*), in varying proportions. In many places, big sagebrush is associated with rabbitbrush (*Chrysothamnus* spp.), short annual grasses, and weeds.

In the northern part of the Area, in Jefferson County, the natural vegetation is mostly big sagebrush, cheatgrass (*Bromus tectorum*), bunchgrasses, and weeds or other herbs. Junipers are scarce in this part of the Area. There are practically none on the Agency Plains or on the plain near Metolius and Culver. A few grow in the moister places near streams and near Juniper Butte and Haystack Butte.

Before the northern part of the Area was used for grazing, bunchgrasses were probably the predominant vegetation (*13*). They are still abundant on rangelands that have not been overgrazed. The predominant bunchgrasses are bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), and Sandberg bluegrass (*Poa secunda*). Other less abundant perennial grasses are needlegrass (*Stipa* spp.), Indian ricegrass (*Orzopsis hymenoides*), thickspike wheatgrass (*Agropyron dasystachyum*), junegrass (*Koeleria cristata*), and giant wild-rye (*Elymus cinereus*) (*8*). Giant wild-rye grows in swales and other moist sites. Idaho fescue is most abundant on deep soils and on moist northern exposures. On the sandy soils, Indian ricegrass, sand dropseed (*Sporobolus cryptandrus*), beardless wild-rye (*Elymus triticoides*), needlegrass, and thickspike wheatgrass commonly predominate (*8*).

In Deschutes County the junipers form an open woodland. The trees are 50 to 100 feet apart, and some are 15 to 20 inches in diameter and 20 or 30 feet tall. The larger trees have a spreading branchy form. The understory of big sagebrush, rabbitbrush, bunchgrasses, annual grasses, and associated herbs is similar to the natural cover on the open range in Jefferson County. The junipers are used to a considerable extent for fuel and posts.

Toward the south, as the elevation becomes higher and the amount of precipitation increases, the junipers and other plants become somewhat larger and the stands denser. In the southern and western parts of the Area, where the annual precipitation is about 12 inches and the altitude is 3,100 to 3,700 feet, ponderosa pines are scattered among the junipers. At about the same elevation or slightly lower, bitterbrush (*Purshia tridentata*) appears as part of the understory. Bitterbrush, also called antelope brush, is a shrub that provides good browse for livestock and big game animals.

Around the southwestern edge of the Area, partly within and partly outside the Area, is a belt 2 to 4 miles wide in which the natural cover consists of an open stand of junipers and ponderosa pines, and an understory of big sagebrush, bitterbrush, rabbitbrush, bunchgrasses, annual grasses, and herbs.

The junipers and big sagebrush gradually give way to ponderosa pines and an understory of bitterbrush mixed with grasses and herbs. In the extreme southern part of the surveyed Area, southwest of Bend, where the annual precipitation is about 13 inches, ponderosa pines predominate over junipers, and the understory is principally bitterbrush mixed with grasses and herbs. In the higher moister places near the western boundary of the Area, some snowbrush (*Ceanothus velutinus*) and greenleaf manzanita (*Arctostaphylos patula*) are associated with the bitterbrush in the understory.

Because much of the Area is farmed, wildlife is less abundant than in the surrounding forests and rangeland. Jackrabbits, pocket gophers, woodchucks, ground squirrels, and coyotes are common, and there are some badgers and porcupines. Pocket gophers, woodchucks, and ground squirrels damage ditches and cause considerable loss of irrigation water. Coyotes kill some poultry and livestock. Deer, which are rather plentiful in the adjoining higher forested region and in the Cascade Mountains, are sometimes found in the Area. Mule deer are the most common. There are some Columbia black-tail deer and a few white-tail deer. Except on rocky talus slopes along the rivers, rattlesnakes are few. Sage hens, pheasants, quail, and ducks are the principal game birds.

Magpies are sometimes pests. The rivers and creeks and many of the lakes in the higher, forested region south and west of the Area and in the Cascades are noted for their trout.

Settlement and Development

Except for nomadic trappers, the first white men known to have visited the Deschutes Area were Gen. John C. Fremont and Kit Carson who, in 1843, traveled across the southern part of the Area near the site of Bend and up the Deschutes River (*13*). The first white settler in this general region located along Hay Creek, east of Madras, in 1863 and herded cattle in the surrounding hills (*13*). Within the next few years, other settlers located on Trout Creek, east of Gateway, on Willow Creek within the present boundaries of the Area, and on Squaw Creek in Deschutes County.

Homesteading started in 1898. After irrigation on a large scale was undertaken, about 1900, many settlers came into the Area. The building of railroads further stimulated settlement. By 1920, most of the arable land was occupied.

Indian wars or skirmishes continued in central and eastern Oregon until about 1879. The Indians now live on the Warm Springs Indian Reservation, just west of the northern part of the Area.

Oregon became a territory in 1848 and a State in 1859 (*1*). Jefferson County was formed in 1914, from what had been the northwestern part of Crook County. Culver was the county seat for the first 2 years; then Madras became the county seat. In 1916, Deschutes County was created from the southwestern part of Crook County.

Early agriculture.—When the Area was first settled, agriculture consisted mainly of raising cattle, sheep, and horses. Grass was abundant in most places, and most ranchers tried to graze their stock on the open range throughout the year without reserve feed. This practice was risky because the winters were severe and the summers very dry.

Within a short time after railroads were built, most of the arable soils in Jefferson County were cleared and used to grow dry-farmed wheat and other small grains, mostly for shipment to outside markets. Wheat crops depended on precipitation. In the drier years yields were low and crop failures were common, especially in the dry areas on the Agency Plains and near Madras and Metolius. Good yields were obtained in probably only 1 year out of 4. After a few successive years of deficient rainfall, much of the less productive land was taken out of cultivation, many homes were abandoned, and some farms were combined into larger units. In the early 1930's, some land in the eastern part of Jefferson County was retired from cultivation and reseeded to grass as part of the controlled-grazing program administered by the Federal Government.

In the early days, some home orchards were planted, and potatoes, corn, and other crops were grown for home use. The orchards did not thrive, and the corn crops often failed. Dairying was not successful because pasture and hay were scarce. In Deschutes County, potatoes were grown under irrigation for shipment to outside markets.

Roads and railroads.—For the early settlers, the nearest shipping point was The Dalles, which is on the Columbia River in Wasco County. Later a branch railroad was built from Biggs, on the Columbia River in Sherman County, to Shaniko, which is in Wasco County but nearer the surveyed Area than The Dalles. The wagon road to Shaniko was rough and hilly, and little produce was transported by wagon except wool. Stock was driven to market. In 1905, a road was constructed from Cross Keys, a stage station 23 miles south of Shaniko, to Bend for use by an automobile stage (*13*).

In 1911, the Oregon Trunk Railway was built. It followed the valleys of the Deschutes River, Trout Creek, and Mud Spring Creek and connected Gateway, Paxton, Madras Station, and Metolius. Also in 1911, the Union Pacific Railroad was extended from the north by way of the valleys of the Deschutes River and Willow Creek. This railroad connected Mecca, which is outside the northwest corner of the Area, with Madras and Metolius. The following year, the Oregon Trunk Railway was extended to Bend, and a branch line of the Great Northern Railway, connecting Bend with Chemult, was built. Later the City of Prineville Railroad was constructed from Prineville Junction eastward to Prineville, in Crook County.

Population

The Deschutes Area consists of the most thickly populated parts of Deschutes County and Jefferson County. The population of Deschutes County was 9,622 in 1920; 18,631 in 1940; and 21,812 in 1950.

The population of Jefferson County was 3,211 in 1920; by 1940 it had declined to 2,042, probably because several years of drought had made dry farming unprofitable. In 1950, after the extension of irrigation, the population had grown to 5,536. In 1950, 36 percent of the population of Deschutes County was classed as rural; all of the population of Jefferson County was classed as rural.

Bend was incorporated in 1904. It became the headquarters of several irrigation projects. Bend is the largest town in the Area. The population increased from 5,415 in 1920 to 11,409 in 1950. Redmond, the second largest town in the Area, was incorporated in 1910. Its population increased from 585 in 1920 to 2,956 in 1950. Madras, the largest town in Jefferson County, was incorporated in 1910. Its population in 1920 was 337, and in 1950 it was 1,258. Metolius, Culver, Opal City, and Gateway are smaller towns in Jefferson County. Terrebonne and Tumalo are smaller towns in Deschutes County.

Industries

Next to farming, the lumber industry is the most important enterprise in the Area. This industry is very important in the southern part of the Area; it is the chief source of income in and around Bend. The lumber comes from the extensive forests south and west of the Area.

Ponderosa pine is the most important commercial tree, but also important are lodgepole pine, Douglas-fir, sugar pine, western white pine, white fir, and incense cedar. Some lodgepole pine is used for poles, posts, and lumber. Juniper is used for posts and to a small extent for wood novelties. Cedar shingles are made in small quantities.

The principal outside markets for lumber are California, the Middle West, and New York (*2*). A considerable amount is sold locally and made into sashes, doors, and box shook, which are shipped to other parts of the country. The byproducts of the sawmills are used for fuel in homes and in power-generating plants.

The extension of the railroad to Bend accelerated the development of the lumber industry. Two large sawmills began operation there in 1916. In 1946 these mills employed about 1,500 people and accounted for 83 percent of the industrial employment in Bend (*6*). Two mills in Redmond that produced finished lumber employed about 130 people in 1946 (*7*). Madras has a smaller sawmill.

A leading wood-using industry is the manufacture of box shook (*2*). Two mills in Bend that make mouldings and special cut stock employed about 50 men in 1946. Two mills in Redmond that make mouldings, box shook, and lath employed 57 people. A furniture manufacturer in Bend employed about 40 people (*6*). Other small establishments in Bend make such things as furniture, cabinets, wood novelties and toys, or treated poles.

Tourists and vacationists bring much income to the Area, particularly to Bend and its vicinity. Visitors are attracted by the varied scenery south and west of the Area. Sportsmen come to fish for trout and to hunt deer, pheasants, ducks, and quail. The dry summer weather is pleasant for camping, horseback riding, and other outdoor activities.

About 60 people, most of whom live in Redmond, Terrebonne, or the surrounding rural area, are employed in mining diatomaceous earth from deposits near Lower Bridge. A little pumice is mined. It is used in making concrete building blocks in Redmond and Bend.

Small dams and electric power plants are located at The Cove on the Crooked River and at Cline Falls on the Deschutes River. These plants and steam power plants at the sawmills in Bend supply electric power for the Area.

Transportation and Markets

Four railroads serve the Deschutes Area. The Oregon Trunk Railway provides freight and passenger service to the north. The Union Pacific provides freight service to the north. The Great Northern Railway gives freight service from Bend southward. The municipally owned City of Prineville Railroad provides freight service from Prineville Junction eastward to Prineville, in Crook County.

The Deschutes Area is well supplied with paved highways. Federal highways, State highways, and local paved roads serve the Area. The local roads are generally good. Most of them are passable throughout the year.

Bus lines connect the towns in the Area with The Dalles and Portland to the north; with Klamath Falls and Lakeview to the south; with Salem, Albany, and Eugene to the west; and with Prairie City and Burns and Boise, Idaho, to the east. Two large common-carrier truck lines maintain service from Bend to Portland, to Spokane, Wash., and to Oakland, Calif. Smaller intrastate carriers operate to other cities.

A scheduled air line provides service north and south from the airport near Redmond. Charter flight service is available from the airport at Bend.

Portland and the nearby districts are the principal markets for most of the agricultural products that are shipped out of the Area. Most of the potatoes are sent there by rail. About 20 percent of the potatoes that are shipped out are hauled by trucks, primarily to the small communities of the Willamette Valley (*3*). Some potatoes are marketed in Washington, and a few carloads are sold in the San Francisco Bay district.

Most of the wheat grown in Jefferson County is sold at markets in or near Portland. Some is sold in Deschutes County. Some barley raised in Deschutes County is sold on the Portland market for brewing and feed. A considerable part of the clover seed and hairy vetch seed is shipped to the southeastern and eastern States.

Cattle and sheep are sold principally on the Portland market; some are sent to San Francisco, and a few are killed in a small local plant. Sheep and wool are marketed through a growers' shipping association. Two creameries in Bend, two in Redmond, and a small one in Madras handle most of the dairy products sold. Local buyers ship some cream to Portland, and producers or distributors sell whole milk and cream in the cities. The cooperative creamery in Redmond processes cream and whole milk into butter and cheese. Turkeys and other poultry are dressed and shipped.

Community Facilities

The elementary schools in the Area are mostly consolidated. There are high schools in Bend, Redmond, and Madras. Students from rural areas are transported by buses to the high schools and consolidated schools. Many denominations have churches in the larger towns. Deschutes, Jefferson, and Crook Counties have a tricounty health unit that employs a staff of full-time nurses. There are two hospitals in Bend and a small one in Redmond. Both of these towns have public libraries.

The Grange, the Farm Bureau, the Farmers Union, the Four–H Clubs, the Future Homemakers of America, and the Future Farmers of America are active in the Area. Vocational agriculture is taught in the high schools at Redmond and Madras. A county fair is held annually at Redmond.

Irrigation and Water Supply

Since the early 1900's, substantial acreages in Deschutes County have been irrigated by water supplied by commercial and cooperative irrigation companies. In Jefferson County, as late as 1945, only a few acres were irrigated by water pumped from the Deschutes River. Between 1945 and 1950, a large acreage in Jefferson County was brought under irrigation.

The data in table 5 show irrigation facilities and their expansion in Deschutes County and Jefferson County since 1940. Most of the irrigated land in the two counties is in the survey Area; consequently the data in table 5 can be considered applicable to the Area.

TABLE 5.—*Data on irrigation in Deschutes and Jefferson Counties, Oreg., in stated years*

[Blank spaces indicate that the item was not reported]

	Deschutes County [1]			Jefferson County [2]		
	1940	1950	1954	1940	1950	1954
Irrigated farms .... number	[3] 940	865	965	[3] 54	460	493
Irrigated land in farms .... acres	[3] 43, 119	[4] 48, 079	44, 424	[3] 3, 779	[4] 39, 635	54, 789
Cropland harvested .... acres	[3] 30, 270	[4] 28, 823	26, 438	[3] 2, 487	[4] 34, 647	48, 581
Pasture .... acres	[3] 12, 849	[4] 16, 707	17, 986	[3] 1, 292	[4] 2, 043	6, 208
Cropland not harvested and not pastured .... acres		[4] 2, 549			[4] 2, 945	
Irrigation enterprises .... number	23	47		42	49	
Average water delivered .... acre-feet		[4] 4. 3			[4] 3. 0	
Diversion dams .... number	39	28		43	89	
Canals and ditches .... miles	846	402		64	398	
Pipelines .... miles	1	2		1	1	
Reservoirs .... number	3	13			2	
Irrigation pumps .... number	[5] 1	29		[5] 8	6	
Pumped wells .... number		3		3	1	

[1] Most of the irrigated land in Deschutes County is in the Deschutes Area.

[2] In 1940, all except a very few of the irrigated farms in Jefferson County were outside the Deschutes Area. In 1950 and 1954, most of the irrigated land in Jefferson County was in the Deschutes Area.

[3] 1939.

[4] 1949.

[5] Pumping plants.

Sources of water

The Deschutes River is the source of most of the water used for irrigation in the Area. This river rises in the Cascade Mountains. It is fed partly by large, steadily flowing springs. Upstream from the irrigation diversions, the flow of the river is remarkably uniform. Below the intakes of the diversion canals, the rate of flow varies. During the irrigation season, generally, there is enough water for irrigation needs.

Although Squaw Creek and Tumalo Creek are outside the Area, they supply much water for irrigation in the Area. Squaw Creek rises near the western border of Deschutes County at the foot of the glaciers of the Three Sisters. It flows northwest and joins the Deschutes River below Lower Bridge. The entire flow of Squaw Creek below the gaging station near McAllister ditch is diverted during summer. Generally, there is not enough water for irrigation needs.

Tumalo Creek rises near the foot of Broken Top Mountain, flows northwest, and empties into the Deschutes River about 2.5 miles above Tumalo. During the irrigation season, generally, there is not enough water in Tumalo Creek to meet irrigation needs.

The Crooked River, which rises in a group of mountains to the east, furnishes very little water for irrigation in the Area, except to a few farms that are supplied by pumping. Nearly all of the flow of the Crooked River above Prineville, in Crook County, is used in Crook County during the irrigation season; a very small flow enters the Deschutes Area in summer. Between Prineville and the junction with the Deschutes River, the Crooked River is fed by many springs, which increase its flow. Near the mouth of the river, the flow is large enough to supply large quantities of irrigation water.

The Metolius River rises outside of the Area at the foot of the snowfields of Mount Washington, Three Fingered Jack, and Mount Jefferson. It is fed by huge springs. It flows into the Deschutes River from the west about 2 miles below the mouth of the Crooked River. At present no water is diverted from the Metolius River for irrigation in the Area.

Water for domestic use and for livestock.—In Deschutes County irrigation water is used on the farms for domestic purposes and for livestock. Water is stored in cisterns for home use and in ponds for livestock. During winter, water is turned into the ditches once a month to fill the cisterns and ponds.

In Jefferson County water for domestic use is pumped from Opal Springs in the Crooked River canyon and piped to Culver, Metolius, and Madras by the Deschutes Valley Water district, which was formed for this purpose only. Most of the farms in these areas and on the Agency Plains obtain water from this source. The water is excellent.

Some water for domestic use is obtained from wells. In much of the upland part of the Area, wells must be about 300 to 700 feet deep. These wells are expensive to drill and to operate. The flow from wells in the sedimentary beds of the Dalles formation is extremely variable; in places it is insufficient for domestic use. Wells drilled in the Clarno formation, in the vicinity of Haystack and Juniper Buttes, generally yield ample water for domestic use. A few springs or seeps occur in this locality. Well water in the Area is usually excellent.

History of irrigation

The history of irrigation in this region has been long and complex. Since 1871, when water was diverted from Squaw Creek to irrigate 45 acres near Sisters just west of the Area, many companies were formed, but most of these companies were short lived. Small companies merged into larger ones, but generally the facilities of the private companies were taken over by landowners who organized irrigation districts. Irrigation districts are cooperative ventures that administer the irrigation of designated areas.

TABLE 6.—*Land in farms according to use in Deschutes and Jefferson Counties, Oreg., in stated years*

[Absence of figure indicates that acreage was not reported]

	Deschutes County				Jefferson County			
	1929	1939	1949	1954	1929	1939	1949	1954
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Land in farms	155, 432	185, 146	298, 108	337, 810	620, 567	697, 232	445, 226	539, 985
Average size of farms	188. 6	176. 8	318. 2	316. 6	1, 852. 4	3, 071. 5	785. 2	915. 2
Cropland total	38, 397	62, 698	60, 808	48, 515	113, 982	87, 311	115, 476	96, 904
Harvested	26, 765	33, 033	33, 996	33, 838	59, 316	24, 870	56, 274	69, 906
Used only for pasture	----------	21, 938	15, 458	8, 157	----------	5, 692	24, 716	3, 889
Not harvested and not pastured	----------	----------	11, 354	6, 520	----------	----------	34, 486	23, 109
Failed	2, 900	2, 661	----------	----------	2, 889	10, 064	----------	----------
Idle or fallow	8, 732	5, 066	----------	----------	51, 777	46, 685	----------	----------
Woodland	34, 003	10, 265	71, 366	109, 549	31, 824	115, 923	67, 874	29, 748
Pastured	28, 462	----------	58, 727	101, 960	29, 994	----------	64, 154	28, 592
Not pastured	5, 541	----------	12, 639	7, 589	1, 830	----------	3, 720	1, 156
Pasture, not woodland and not cropland	54, 961	----------	154, 669	163, 915	459, 662	----------	252, 818	395, 143
Pasture total	89, 130	----------	228, 854	274, 032	498, 920	----------	341, 688	427, 624
Other land	22, 364	[1] 112, 183	11, 265	15, 831	5, 835	[1] 493, 998	9, 058	18, 190

[1] Includes pasture that was not woodland and not cropland.

Construction of storage facilities began in the mid-twenties, when it became apparent that the flow of the streams was not large enough to supply all projects at the time the water was needed. Several reservoirs were built to supply irrigation districts.

Before 1945 most of the irrigation in the Area was in Deschutes County. Since 1945 about 50,000 acres have been irrigated in Jefferson County north of the Crooked River in the North Unit of the Deschutes Irrigation Project.

Irrigation practices and problems

The irrigation season commonly extends from the first of April to the middle or last of October. Water is delivered to farms by a continuous flow in most of the districts. This practice necessitates constant attention, and at times the head of water is smaller than that needed. In the Squaw Creek district, a turn-flow system is used. Under this system fewer ditches are used at one time, and the head of water is larger than it would be if more ditches were used. A rotation system is used in some of the ditches of the Swalley district.

A serious problem for all the districts is conveyance loss, that is, loss of water between the point of diversion and the irrigated field. Conveyance loss may be as much as 30 to 65 percent. The loss is high largely because the canals are not lined and the sandy, pumiceous soils and permeable underlying material absorb water rapidly.

Agriculture

The Deschutes Area is approximately half in Deschutes County and half in Jefferson County. In Deschutes County agriculture under irrigation has prevailed for many years; some livestock has been raised on the range, but there has been very little dry farming. In Jefferson County dry farming of wheat has prevailed; some livestock has been raised on the range. The differences in the systems of agriculture are reflected in the size of farms, the use of the land, and in other ways. The North Unit of the Deschutes Irrigation Project, under development at the time of the survey, will supply water to irrigate that part of the Area that is in Jefferson County.

Land Use

Table 6 shows the total acreage in farms and the acreage in farms according to use, in all of Deschutes County and Jefferson County in 1929, 1939, 1949, and 1954. An estimated three-fourths of the cropland in the two counties is in the surveyed Area.

Crops

Table 7 gives the acreage of the principal crops in all of Deschutes County and Jefferson County for 1939, 1949, and 1954. Since three-fourths of the cropland of the two counties is in the surveyed Area, the data are representative of the Area. Between 1939 and 1949, the pattern of agriculture in Jefferson County changed significantly, as a result of the extension of irrigation in the North Unit of the Deschutes Irrigation Project. The major changes are reflected in table 7.

Minor crops grown in the Area are corn, strawberries, red raspberries, peppermint, onions, green peas, sweet corn, alfalfa for seed, crested wheatgrass for seed, Chewings fescue for seed, sweetclover for hay, apples, and peaches. Both irrigated pastures and range are important.

Potatoes.—Potatoes are grown throughout the irrigated parts of the Area, except in the extreme southern and southwestern parts where the soils are sandy and the frost hazard is high. They have been the principal cash crop in Deschutes County ever since the railroads provided transportation to markets, but hardly any were grown in Jefferson County before the North Unit of the Deschutes

TABLE 7.—*Acreage of principal crops in Deschutes and Jefferson Counties, Oreg., in stated years*

	Deschutes County			Jefferson County		
	1939	1949	1954	1939	1949	1954
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Winter wheat threshed	283	345	1, 335	15, 117	12, 072	13, 189
Spring wheat threshed	1, 323	1, 238	1, 223	3, 210	13, 605	14, 890
Barley threshed	2, 032	3, 797	1, 791	419	6, 511	13, 126
Oats threshed	2, 789	2, 331	1, 736	58	706	1, 344
Oats cut for feeding	426	370	(1)	(1)	251	(1)
Rye threshed	693	1, 036	(1)	265	90	(1)
Mixed grains threshed	114	159	93	(1)	322	402
Other grain threshed	(1)	1, 041	1, 808	(1)	90	275
Clover for seed	4, 642	1, 722	509	(1)	9, 172	3, 375
Potatoes	1, 884	3, 746	[2] 2, 435	9	2, 001	[2] 5, 984
All hay	17, 099	18, 590	22, 427	5, 418	10, 486	15, 058
Alfalfa	11, 235	11, 329	13, 252	2, 067	7, 849	9, 881
Clover or timothy, alone or mixed	359	870	971	38	279	611
Small grains cut for hay	4, 928	5, 185	7, 494	3, 255	2, 044	2, 709
Wild hay	272	203	217	(1)	95	462
Other	305	1, 002	493	58	219	1, 395

[1] Not reported.
[2] Does not include acreage of farms that had less than 10 bags harvested.

Irrigation Project was completed. Potatoes are seldom grown on the inadequately drained Odin soils, and are grown on only a small acreage of the fine-textured Redmond soils.

Potatoes are normally grown in rotation with alfalfa, clover, or pasture, but they may be grown on the same acreage for 2 or more successive years. They are planted in April or May, by machine. Generally a complete fertilizer is applied. Irrigation is by the furrow method. Many soils in the Area apparently need only a small amount of irrigation water (*11*). Late in fall, the potatoes are dug by machines and picked up by hand. The Area is quarantined to keep bacterial ring-rot out. The potatoes are blocky and well shaped, easily cleaned, and attractively colored. They have a low peeling loss. Production of certified seed potatoes has been profitable in Deschutes County for several years (*14*).

Wheat.—After the extension of railroads into the Area, dryland wheat became the chief cash crop of the nonirrigated part of the Area in Jefferson County. In much of this region the normal annual precipitation is about the minimum for growing dryland wheat. A very dry year or a series of dry years results in a significant decrease in the acreage of wheat.

Under dryland farming, winter wheat gives better yields than spring wheat. Winter wheat is planted late in October or early in November and harvested the following August or September. Wheat is grown every other year. In the alternate years the stubble is plowed in the spring and a trashy fallow is left through the summer. To control weeds the fields are cultivated with a rod-weeder or other implement three or more times during the summer. Since the extension of irrigation in Jefferson County, the acreage of winter wheat has decreased and the acreage of irrigated spring wheat has increased.

In Deschutes County, where large areas have been irrigated for many years, wheat is less commonly grown. When wheat follows potatoes in the rotation, it is usually spring wheat. More spring wheat than winter wheat is grown in the vicinity of Cloverdale and Bend, where the frost hazard is serious.

Oats.—Oats are grown only in the irrigated parts of the Area. Most of the crop is either combined or cut with a binder, shocked in the field, and threshed. Some of it is used unthreshed for feed. Practically all the oats grown are fed on the farm.

Barley.—Barley is widely grown under irrigation. It is harvested in the same way as wheat. Most of it is used for feed in the Area, but a small part is exported. Small acreages of dry-farmed barley have been grown in Jefferson County.

Rye.—Only a small acreage of rye is grown in the Area. Most of this is grown under irrigation. A small acreage of dry-farmed rye is grown in Jefferson County in the western part of the Area. Yields have been low. Almost all the rye grown is used for feed.

Alfalfa.—Alfalfa, the principal hay crop, is grown throughout the irrigated parts of the Area. It generally follows a grain crop. It is commonly fertilized with light applications of sulfur or gypsum. A considerable part of the crop is baled in the field. Some unbaled hay is put into barns, some is stacked, and a little is ground or chopped. Two or three cuttings a season are obtained. Nearly all the alfalfa hay is fed on the farm.

Alsike clover.—Alsike clover grown for seed has been one of the most important cash crops in the irrigated districts. Yields are fairly high and can be increased if the crop is fertilized with sulfur and phosphorus and if there are enough bees for pollination. Most of the seed is shipped to the eastern part of the country.

Oats and barley are commonly used as nurse crops in seeding the alsike clover; winter-sown grain is less suitable for this use. Most of the alsike clover is harvested by a combine, and the straw is spread on the ground. Two seed crops are obtained from one planting in places where damage from weeds and insects is not serious, but the second-year crop may be unprofitable because of weeds.

In 1947, several hundred acres in the newly irrigated

North Unit were used successfully for this crop. The newly irrigated soils produce good yields because they are practically free of weeds.

Other legumes.—Ladino clover grown for seed has become an important crop on the newly irrigated soils in Jefferson County. These soils are still relatively free of weeds and insects, and they produce high yields of good seed. According to an estimate by the Oregon Farmer, about 440 acres of Ladino clover was harvested for seed in 1947. The average yield was estimated at about 270 pounds of seed an acre.

Ladino clover is commonly sown in the spring in a nurse crop of barley that has been lightly fertilized with sulfur. If there is no nurse crop, the clover can be planted any time between April and September; it should be fertilized with sulfur. There should be enough bees to pollinate the crop. Two crops of seed are generally obtained from each planting; after the second seed crop, the clover is cut for hay or used for pasture.

Ladino clover is not extensively grown for seed in Deschutes County, because the stand is likely to be invaded by weeds and alsike clover.

Hairy vetch is a suitable seed crop for irrigated soils. It needs little water. It is a 1-year crop, but it can be grown on the same field for successive years. It reseeds itself and requires little soil preparation. It can be seeded during slack periods in winter and harvested early so that, by midseason, irrigation water can be used for other crops. The straw can be plowed under or used as winter feed for livestock.

The seed must be harvested at the right time to minimize losses that result from cutting when the vetch is too green and from shattering. Because it reseeds voluntarily, hairy vetch is generally followed by potatoes or pasture instead of winter grain.

Garden peas, for seed, is a newly introduced crop on soil recently brought under irrigation in Jefferson County in the North Unit; in 1946, this crop was grown on about 950 acres of soil irrigated for the first time.

The acreage of Austrian peas grown in Deschutes County has declined because of a decrease in the price of the seed and the infestation by aphids and weevils.

Only a small amount of red clover has been grown for seed in Deschutes County. Since the irrigation of the North Unit, however, the acreage of this crop has increased. On dairy or livestock farms, red clover is somewhat better suited than alsike clover because the red clover can be cut for hay by the first of June or can be pastured until about the middle of May.

Minor field crops.—Some corn has been grown in Deschutes County, but the climate is not suitable for corn. A small amount of crested wheatgrass has been harvested for seed in Deschutes and Jefferson Counties. At times a few acres of Chewings fescue is grown for seed.

Vegetables.—Vegetables, other than potatoes, are minor crops. In some years a few acres of onions are grown for sale and shipment out of the Area. String beans, cabbage, carrots, green peas, lettuce, and other vegetables are grown mainly for home use and local sale. Possibly some onions, sugar beets, carrots, and lettuce will be grown for seed in the North Unit.

Fruits.—Orchards and vineyards occupied 18 acres in Deschutes County and 14 acres in Jefferson County in 1954. The few farms that specialize in tree fruits or grapes are in the canyons of the Deschutes and Crooked Rivers. At these low altitudes frosts are less injurious, and the growing season is fairly long. In 1954, strawberries were harvested on 9 acres and raspberries on 9 acres in Deschutes County. Some of these small fruits are sold locally.

Permanent Pasture

Most of the permanent pasture in the Area is nonirrigated range. It consists chiefly of areas of Scabland and associated shallow and stony soils and of strongly sloping and steep areas of other soils. The natural range vegetation is mostly big sagebrush, bunchgrasses, cheatgrass, and herbs. In places this vegetation is mixed with rabbitbrush and western juniper. In the extreme southern and southwestern parts of the Area it is mixed with ponderosa pine and bitterbrush.

Much of the range is in poor or very poor condition. It is used mostly for spring and fall grazing. The carrying capacity is low.

A large acreage, mostly in Jefferson County, that was formerly dry farmed has been seeded to crested wheatgrass. Most of this acreage was purchased by the Federal Government in the 1930's and is now administered as a grazing project by the Soil Conservation Service.

Where the range is in excellent or good condition, the bunchgrasses are abundant, and most of the plants associated with the bunchgrasses are good for forage.

Where the range is in poor or very poor condition, most of the forage is furnished by cheatgrass, also called downy chess or downy brome, an annual or summer annual grass native to Europe. It is now common in this general region and, in places, predominant. Squirreltail and annual fescue occur in places.

Other plants commonly associated with bunchgrasses—balsamroot (*Balsamorhiza* spp.), lupine (*Lupinus* spp.), hawksbeard (*Crepis* spp.), yarrow (*Achillea* spp.), wildbuckwheat (*Eriogonum* spp.), pussytoes (*Antennaria* spp.), wild onion (*Allium* spp.), and biscuitroot (*Cogswellia* spp.)—are less abundant than the grasses and are of less value for forage. Plants that occur as weeds on deteriorated ranges include tumblemustard (*Norta altissima*), also known as Jim Hill mustard, an invader of European origin; Russian-thistle (*Salsola pestifer*), a native of Eurasia; fanweed, tarweed; and fiddleneck (*8*).

Most of the permanent irrigated pastures are on shallow and stony soils, strongly sloping or steep areas, the inadequately drained Odin soils, or fields convenient to the barn. Bluegrass and whiteclover are the common pasture plants. Some of the better and more productive pastures are in a mixture of alta fescue, orchardgrass, smooth brome, meadow foxtail, perennial ryegrass, Ladino clover, white clover, and alsike clover. A few pastures are grazed in rotation, and on some farms sulfur or gypsum, phosphorus, and nitrogen fertilizers are applied.

Livestock and Livestock Products

Table 8 gives the number of livestock on farms in 1940, 1950, and 1954 in all of Deschutes County and Jefferson County. In Deschutes County in 1954, 150 farms were classified as livestock farms, 101 as dairy farms, and 41 as poultry farms. In that year in Jefferson County, 96

TABLE 8.—*Number of livestock on farms in Deschutes and Jefferson Counties, Oreg., in stated years*

Livestock	Deschutes County			Jefferson County		
	1940	1950	1954	1940	1950	1954
Horses and mules	[1] 2,769	1,651	1,313	[1] 1,499	1,033	958
Cattle and calves	[1] 10,243	13,384	24,437	[1] 9,845	11,831	24,805
Milk cows	4,452	3,567	3,383	507	1,024	1,213
Swine	[2] 3,350	2,967	2,260	[2] 598	1,745	1,865
Sheep	[3] 12,794	3,468	5,375	[3] 28,305	13,890	12,142
Chickens	[2] 44,781	[2] 41,945	[2] 49,581	[2] 7,532	[2] 12,155	[2] 20,839
Turkeys raised	104,358	[4] 43,894	43,135	2,206	[4] 65	220
Other poultry raised	399	407	661	([5])	152	213
Beehives	952	[4] 1,477	([5])	31	[4] 141	([5])

[1] Over 3 months old.
[2] Over 4 months old.
[3] Over 6 months old.
[4] 1949.
[5] Not reported.

farms were classified as livestock farms, 5 as dairy farms, and none as poultry farms.

Beef cattle.—Beef cattle are an important source of income in the Deschutes Area. Before the North Unit was irrigated, beef cattle enterprises in Jefferson County were dependent on the carrying capacity of the ranges and the supply of winter feed, both of which varied according to the amount of precipitation.

In Deschutes County, cattle are grazed on range and irrigated pasture. From 1940 to 1945, the number of cattle raised for beef increased, partly because sheep were replaced on the range and dairy cattle were replaced on the irrigated farms. The number of cattle in both Deschutes and Jefferson Counties continued to increase from 1950 to 1954.

Hereford and Shorthorn are the dominant breeds; several herds are purebred. Most of the cattle are shipped to Portland. A few are sold to local butchers.

Dairy cattle.—Most of the dairy farms are in the irrigated districts near Redmond and Bend where creameries process whole milk and cream into butter and cheese. Irrigation of the North Unit will probably be followed by an increase in dairying in that part of the Area.

Most of the dairy cattle are Jersey or Guernsey; some are Holstein. A large part of the feed is raised on the farm, but some of it is bought, particularly corn, other grain, and mixed feed.

Turkeys.—Many turkeys are raised in Deschutes County, but only a few are raised in Jefferson County. Several specialized commercial farms raise thousands of turkeys per year; many diversified farms raise smaller flocks for market. Rape, alfalfa, clover, sunflowers, and some grain normally are grown for turkey feed, and a considerable quantity of mixed feed is bought. The turkeys are dressed and prepared for shipment in Redmond.

Other Poultry.—Chickens are generally raised in small flocks as a sideline to other types of farming. Leghorn, Rhode Island Red, and New Hampshire are common breeds. About enough chickens are raised to supply the local markets. The distance to large markets and the competition from other areas discourage expansion of the chicken industry. Only a few ducks, geese, and guineas are raised.

Sheep.—More sheep have been raised in Jefferson county than in Deschutes County. In Jefferson County the sheep are kept on the range in spring, summer, and fall. In winter they are fed hay. Since irrigation of the North Unit began, the number of sheep in Jefferson County has declined.

The number of sheep in Deschutes County has decreased sharply since 1935. Most of the operators of large sheep ranges have changed to raising other livestock or have gone out of the livestock business (*14*). A considerable proportion of the sheep are in small bands on irrigated farms where nearly all the feed is grown on the farm. The medium-wool breeds predominate. Common breeds are Corriedale, Oxford Down, and Rambouillet.

Swine.—Only a few swine are raised in the Area. The number raised depends somewhat on the amount of available skim milk, cull potatoes, and other farm byproducts and waste. Swine are more common on the irrigated farms than on the nonirrigated ones. Practically all the hogs are sold to local butchers or butchered on the farm.

Farm Power and Mechanical Equipment

The number of work horses and mules on farms has decreased with the increase in mechanization. In 1954, 450 farms in Deschutes County reported having 1,313 horses and mules, and 250 farms in Jefferson County reported having 958 horses and mules. Most of the horses are good draft breeds, but many horses are kept mainly for riding.

The kind and quantity of mechanical equipment on the farm depend on the type of farming. The large dryland wheat farms in Jefferson County are highly mechanized. The typical farm has one or more large caterpillar tractors that furnish the power for most of the field operations. Other common equipment on these farms include gang plows, spike- or spring-toothed harrows, rod weeders, grain drills, a large combine, and one or more trucks. In contrast, the cattle or sheep farms that depend largely on ranges for grazing have few or no large implements, except possibly a mower and other hay-making equipment. Some of these farms depend on horses or trucks for power. Heavy equipment is not common on irrigated farms.

In 1954, there were 926 tractors on 691 farms in Deschutes County and 941 tractors on 477 farms in Jefferson County. Most of these tractors are of the small or medium wheel type. Tractor-drawn or horse-drawn plows of various sizes are used. Most farms are equipped with a small or medium spike- or spring-toothed harrow, disk, grain drill, hay mower, hayrake, hay-stacking equipment, and either a grain binder or a small combine. Some custom work is done with rather small combines, grain binders, threshing machines, ensilage cutters, hay choppers, hay bailers, potato graders, seed cleaners, and leveling equipment. Most farms on which potatoes are grown for sale are equipped with potato planters and one-row potato diggers. In 1954, there were 891 trucks on 688 farms in Deschutes County, as compared to 383 trucks on 347 farms in 1945.

Type and Size of Farms

In 1954, 150 farms in Deschutes County were classified as livestock, 101 as dairy, 41 as poultry, 158 as general, and 77 as field crop; 549 farms were not classified. In 1954, 96 farms in Jefferson County were classified as livestock, 5 as dairy, 91 as general, 290 as field crop, and 5 as fruit and nut; 45 farms were not classified.

The 1,067 farms in Deschutes County in 1954 covered 337,810 acres, an average of 316.6 acres per farm. The 590 farms in Jefferson County in 1954 covered 539,985 acres, an average of 915.2 acres. In recent years large farms have become more numerous in Deschutes County; in Jefferson County the number of farms larger than 1,000 acres has decreased and the number of farms smaller than 1,000 acres has increased.

Farm Tenure

In 1954, owners and part owners operated 979 farms in Deschutes County, tenants operated 83, and managers 5; the owners and part owners operated almost 92 percent of the total number of farms. Tenancy decreased from 20.3 percent in 1940 to 7.8 percent in 1954.

In 1954, owners and part owners operated 450 farms in Jefferson County, tenants operated 134, and managers 6; the owners and part owners operated about 76 percent of the total number of farms. Tenancy increased from 15.0 percent in 1940 to 22.7 percent in 1954.

One common rental arrangement is for the operator to pay all operating expenses and to deliver to the owner one-quarter of the potatoes, one-third of the grain, and one-half of the hay. Another common system is for the operator and the owner to divide the cash expenses and the crops equally.

Farm Home Facilities

In 1954, 1,052 farms in Deschutes County had electricity and 838 had telephones; in Jefferson County 498 farms had electricity and 386 had telephones. The same year, 928 farms in Deschutes County and 472 farms in Jefferson County had running water. In both counties almost all the farmhouses are heated by wood stoves. In 1954, on 879 farms in Deschutes County there were 1,117 automobiles; on 486 farms in Jefferson County there were 639 automobiles.

Soil Survey Methods and Definitions

Soil surveying consists of the examination, classification, and mapping of soils in the field. The soil scientist walks over the area at intervals of not more than one-quarter of a mile and bores into the soil with an auger or digs holes with a spade. Each such boring or hole shows the soil to consist of several distinctly different layers or horizons, collectively known as the soil profile. Each of these layers is studied carefully for the things about it that affect plant growth.

The color of each layer is noted. The darkness of the topmost layer is usually related to its content of organic matter; streaks and spots of gray, yellow, and brown in lower layers generally indicate poor drainage and poor aeration.

Texture, or the content of sand, silt, and clay in each layer, is determined by the way the material feels when rubbed between the fingers. Texture is later checked by mechanical analysis in the laboratory. Texture has much to do with the quantity of moisture the soil will hold available to plants, whether plant nutrients or fertilizers will be held by the soil in forms available to plants or will be leached, and how difficult the soil may be to cultivate.

Soil structure, or the way the soil granulates and the size and number of pore spaces between particles, indicate how easily plant roots can penetrate the soil and how readily water enters it.

Consistence, or the tendency of the soil to crumble or stick together, indicates how difficult it is to keep the soil open and porous under cultivation.

The kinds of rocks or mineral material from which the soil has been developed, or its parent material, affects the quantities and kinds of plant nutrients the soil may have naturally. Simple chemical tests show how acid the soil may be. The depth to bedrock, cemented or compact layers, or loose gravel strata is determined. The presence of gravel or rocks that may interfere with cultivation, the steepness and kind of slope, the quantity of soil lost through erosion, and other external features are observed.

On the basis of all these characteristics, soil areas that are much alike in the kind, thickness, and arrangement of their layers are mapped as one soil type. Some soil types are separated into two or more phases. For example, if a soil type has slopes that range from 0 to 7 percent, the type may be mapped in two phases, 0 to 3 percent slopes and 3 to 7 percent slopes; or a soil that has been eroded in places may be mapped in two or more phases, an uneroded (or normal) phase and an eroded phase. A soil type is divided into phases primarily because of differences in the soil other than those of kind, thickness, and arrangement of layers. Examples of characteristics on the basis of which a soil type might be divided into phases are slope, the number of outcrops of bedrock, the extent of erosion, the degree of drainage, and the nature of or depth to underlying material.

Two or more soil types may have similar profiles; that is, the soil layers may be nearly the same except that the texture, especially the texture of the surface layer, may differ. As long as the other characteristics of the soil layers are similar, these soils are considered to belong in the same soil series. A soil series, therefore, consists of all the soil types that, except for texture, particularly texture of the surface layer, have about the same kind, thickness, and arrangement of layers.

The name of a place near where a soil series was first found is chosen as the name of the series. Thus, Redmond is the name of a soil series in Deschutes County first recognized near Redmond. Three types of the Redmond series are mapped—Redmond sandy loam, Redmond loam, and Redmond clay loam. These soil types differ in the texture of the surface soil, as their names show. Redmond sandy loam is divided into two slope phases, areas of soils having 0 to 3 percent slopes and areas having 3 to 7 percent slopes. The normal phase of Redmond sandy loam is between 16 and 36 inches deep to bedrock, and it is called Redmond sandy loam. Where the depth to bedrock is greater than 36 inches, the soil is called Redmond sandy loam, deep.

Steep rocky mountainsides, loose coarse material in stream channels, and other areas that have little or no true soil are not given soil series and type names. They are considered to be land types and are given descriptive names such as Rough stony land, Riverwash, and Scabland.

The soil type, or if the soil type is subdivided, the soil phase, is the unit of mapping in soil surveys. It is the unit, or the kind, of soil that is most uniform and has the narrowest range of characteristics. For this reason, soil use and management practices can be more definitely specified for it than for broader groups of soils that contain more variation. One can say, for example, that soils of the Deschutes series need additions of organic matter for intertilled crops. In contrast, for Deschutes sandy loam, 0 to 3 percent, it can be said that it needs organic matter and is suited to row crops grown in short rotations. Then, for Deschutes sandy loam, 7 to 12 percent, it can be stated that it is difficult to irrigate, erodes easily, and should be used principally for long-term hay or pasture. Both of these phases are in the Deschutes series.

The soil surveyor makes a map of the county that shows the location of each of the soil types, phases, complexes, and miscellaneous land types in relation to roads, houses, streams, lakes, section and township lines, and other local cultural and natural features of the landscape.

Morphology, Genesis, and Classification

Factors of Soil Formation

Soil is the product of the forces of the environment acting on the parent soil materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by: (1) the physical and mineralogical composition of the parent soil material; (2) the climate under which the soil material has accumulated and developed; (3) the plant and animal life in and on the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of development have acted on the material. The influence of climate on soils depends not only on temperature, rainfall, and humidity, but also on the relief and the physical characteristics of the soil or soil material. The relief, in turn, strongly affects drainage, aeration, runoff, erosion, and exposure to sun and wind.

Climate and vegetation change the parent material from an inert, heterogeneous mass to a body having more or less definite genetic morphology. Their action on the parent material is hastened or hindered to varying degrees by the relief, which helps to determine runoff, natural erosion, the movement of water through the soil, and the natural vegetation. As time passes during the genesis of soil, the slow natural processes cause changes in the soil; hence, time is a factor in the development of the soil into a body that is in equilibrium with its environment. The degree of soil development depends not only on time but also on the rate at which the forces of climate and vegetation act. These forces, in turn, are conditioned somewhat by the relief and parent material.

Parent materials

The Clarno formation (Eocene), which is the oldest exposed formation in the Area, underlies Juniper Butte, Haystack Butte, Gray Butte, and the adjoining hilly, higher region to the east. This formation consists mainly of large massive agglomerates, breccias, tuffs, ashes, and other volcanic materials. It also includes gravels, sands, and clays that were carried by streams from nearby areas and by many lava flows. The lava consisted mainly of rhyolite, but included andesites and basalts (*5*). Because much of the Clarno formation resists geologic erosion, several high peaks occur. The strata of this formation are variously colored; they are exposed in Smith Rock near the Crooked River. Some of the Lamonta, Agency, and Era soils and areas of Rough stony land and Rough broken land overlie materials of the Clarno formation.

Basalt, called Trail Crossing basalt (Eocene?) (*15*), occurs east of Haystack Butte, where it is apparently intercalated in the tuff beds of the Clarno formation. The Gem soils and Rough stony land have formed on this basalt.

The John Day formation (Oligocene) is exposed only in the northern part of the Area in the lower part of the canyons of the Deschutes River and Trout Creek. This formation is white, buff, or varicolored. It is composed largely of volcanic ashes and tuffs. All exposed areas are steep talus slopes or cliffs that extend below a rimrock strata of lava. They are mapped as Rough stony land.

The Columbia River basalt, or Coriba formation (Miocene), at one time lay upon the John Day formation, but it has been eroded away or buried beneath other material in most of the surveyed Area (*5*). It is exposed mainly as rimrock or other strata in the canyons of the Deschutes River and Trout Creek in the northeastern part of the Area. Much of the exposed area of this formation is mapped as Rough stony land, but probably some of the Agency, Era, and Lamonta soils overlie this formation.

The Dalles formation (Pliocene) (*5*), also called the Deschutes formation (*15*), overlies Columbia River basalt at or near the surface in much of the surveyed Area in Jefferson County and in places in the northern part of Deschutes County. Most of the materials of this formation are of volcanic origin and consist of horizontal beds of water-spread materials intercalated with lava flows, mainly basalt. The fluvial beds consist of sandstones, agglomerates, agglomerate mudflows, gravels, sands, silt, tuffs, cinders, volcanic ashes, and, in places, diatomite.

The sandstones, agglomerates, mudflows, and tuffs are more or less consolidated, but some of the materials are loose or only weakly consolidated.

Streams readily cut the fluvial beds, but the interbedded lava flows are resistant to geologic erosion and form rimrock. Beneath the edges of the rimrock, the water-laid sediments are easily carried away and the edges break off. As these beds are nearly horizontal, a plain forms when they are eroded down to one of the interbedded lava flows. The nearly level Agency Plains north of Madras is largely preserved because its northwestern side is protected by the underlying resistant Columbia River basalt. Remnants of similar plains lie west of Madras and near Metolius, Culver, and Opal City.

A mature topography of rolling hills forms where the rimrock has been removed and a thick section of the water-laid sediments is exposed to erosion. The basin at and east of Madras that extends from Gateway to Haystack Butte was formed in this way. In this basin the intermittent streams have formed a dendritic pattern, but further downcutting is prevented, at a temporary base level, by the underlying Columbia River basalt near Gateway (*5*). Some of the Madras, Agency, Era, and Lamonta soils were derived from these thick water-laid sediments overlying basalt.

The Cascan formation (late Pliocene) lies above the Dalles beds in part of the area west of the Deschutes River (*5*). It consists mainly of andesitic lava flows; much agglomerate, tuff, and ash; and some dacites, basalts, and rhyolites. But most of this formation in the surveyed Area is covered by water-laid gravel and sand, possibly of glacial outwash origin. These areas are nearly level. In places the material resembles unassorted or poorly assorted glacial drift.

In late Pleistocene or Recent time, after the rivers had cut canyons about 1,000 feet deep, volcanoes again erupted in the southern part of the Area, particularly near Bend and southward. From volcanoes near Bend and perhaps from local vents elsewhere, very liquid olivine-basalt lava flowed great distances northward and in places spilled into the valleys of the Crooked and Deschutes Rivers (*5* and *15*). Flows entered the Deschutes River north of Bend and near Tetherow Bridge, the latter flow filling the canyon for several miles downstream. One flow entered the Crooked River east of the surveyed Area and flowed down the canyon to below its junction with the canyon of the Deschutes River. Since then the Deschutes River and the Crooked River have cut narrow box canyons with vertical sides in this intracanyon basalt, practically to the level of the original canyons. Below Opal Springs the box canyon cut by the Crooked River is 465 feet deep. The railroad bridge over this box canyon south of Opal City is about 340 feet long and 320 feet above the river.

This intracanyon basalt covered most of the surveyed Area in Deschutes County east of the Deschutes River, except some of the northern part. The surface of the upland lava is vesicular, ropy, and ragged. It has many split mounds, blisters, or "bread crust" swells. The lava may contain opals (*15*). The original topography has been practically unchanged by geologic erosion, and practically no streams have formed. The plain is undulating or somewhat rolling. It consists of alternating narrow ridges, mounds, or swells of outcrops of basalt, and very stony soils or Scabland and intervening swales or disconnected shallow basins. Many of these swales or basins have no surface drainage outlet, but only a few are too poorly drained for the common crops. A few are ponded and need a well drilled into the basalt or an open ditch for an outlet. The arable areas consist of the deeper soils in these swales and basins and in the level areas between the ridges of Scabland. The Redmond and Odin soils and some of the Deschutes soils occur in these areas.

Subsequent to the intracanyon lava flows, a mantle of windborne, very pale brown or light yellowish-brown pumice was laid down over the area. Apparently the pumice is composed of glassy hypersthene-augite dacite with accessory hornblende (*16*). Its source probably was the former volcano (Mt. Mazama) at Crater Lake, although some of it may have come from Newberry Crater, Devil's Hill, or another volcano of the region. In the southern part of the Area, the pumice mantle is about 2 or 2.5 feet thick on the level areas between ridges of Scabland. Apparently water or wind have removed much, and in places all, of the pumice mantle from the ridges of Scabland. Probably the pumice accumulated in the intervening lower flats or basins. To the north, the pumice mantle is thinner than in the south and is composed of fine particles. In the southern part of the Area, the pumice contains a considerable amount of particles the size of coarse and very coarse sand. In Jefferson County north of Juniper and Haystack Buttes, most of the pumice particles are the size of medium and fine sand or smaller, and no distinct mantle of pumice is apparent. Fine volcanic ash and volcanic dust likely were carried across the Area. The Deschutes, Laidlaw, Redmond, and Odin soils were derived principally from this pumice.

Relatively minor quantities of other windborne silt or loess may have been deposited on the soils in the northern part of the Area.

Climate

In the semiarid microthermal climate of the Area, zonal soils of the Brown great soil group have formed. Although the total precipitation is rather low, the relatively high altitude and cool summers cause less evaporation, and moisture is therefore used effectively in the formation of soils. Not enough rain falls to leach the soils strongly, but the upper few inches of many of the virgin soils are neutral to slightly acid. Only a small part of the precipitation falls during the hot months when evaporation is highest; the soils, therefore, are leached to a greater depth than in regions that have about the same annual precipitation but a higher proportion of it in summer.

In general, the total precipitation increases with increase in altitude and with the approach to the Cascade Mountains. Juniper Butte, Haystack Butte, and the surrounding higher area apparently receive a few inches more precipitation than Redmond and Madras. East and southeast of Haystack Butte, at an altitude higher than that in most of the Area and on a northward exposure, soils of the Chestnut great soil group have formed under an annual precipitation of 11 to 12 inches. In these soils, calcium carbonate is leached to a somewhat greater depth than in other soils of the Area.

From Redmond west, southwest, and south toward the Cascades and other high mountains, the precipitation increases to about 13 inches or slightly more at the border of the surveyed Area. This precipitation should be favorable for the formation of Chestnut soils. The soils, however, are forming in somewhat coarse sandy pumice of Recent age, and they are not typical Chestnut soils. They resemble azonal soils of the Regosol great soil group but perhaps should be considered Brown-Brown Podzolic transitional soils that have minimal development. Not much organic matter has accumulated in these soils. The coarse texture and higher precipitation have caused the little calcium carbonate that has formed in them to be leached deeply into or from the profile.

Vegetation and animal activity

The soils in most of the Area were formed under a cover of big sagebrush, bunchgrasses, widely spaced junipers, and associated rabbitbrush, annual grasses, and herbs. In the southern half of the Area where the soils were formed in a mantle of pumice, the junipers are larger and somewhat denser than they are in other regions. Because the vegetation is rather sparse in most of the Area, light-colored soils that are relatively low in organic matter were formed.

In the vicinity of Haystack Butte, where precipitation was higher, the vegetation was similar to that of the rest of the Area, but it was more luxuriant. In this region the soils are darker and contain more organic matter.

In a small part of the surveyed Area along the southern and western borders, the precipitation is higher, the altitude greater, and the summer cooler than in the rest of the Area. Here there is a scattered growth of ponderosa pine mixed with juniper and an understory of bitterbrush, big sagebrush, and grasses. In these areas the precipitation—12 to 13 inches or slightly more—is low for the growth of ponderosa pine. The pumicy material in the soil apparently accounts for the growth of pine and the good growth of juniper. The pumice is vesicular and holds more moisture than other materials of similar texture. It is not, however, suitable for a dense growth of grasses, and the accumulation of organic matter in the soil has been low. Not enough leaf litter has accumulated under the pines and junipers to form a continuous layer. Under the junipers, the litter is as thick as 1 to 2 inches at the base of the trunks of old trees, but there is little or no litter a few feet from the trunk.

The activity of animals, particularly rodents and ants, probably has affected the development of the soil considerably. Ant hills are numerous. Fragments of caliche have been brought to the surface by rodents in digging their burrows. Animals mix the materials of the various horizons and slow the formation of soil horizons.

Relief

Relief has been important in the development of some of the soils; in others it has been less significant. Madras soils, for example, are characterized by caliche in the lower subsoil, but this pan is much more weakly cemented in the strongly sloping soils than it is in the nearly level ones. Similarly, the profile development of the strongly developed Lamonta soils is weaker in areas of greater slopes. The Deschutes soils, however, which have developed in pumicy material, are little affected by a wide range of slopes.

Much of the Area is nearly level, undulating, or rolling. Most of the steep and hilly regions of the buttes and canyons along the rivers and creeks have been included in Rough stony land and Rough broken land. In the steepest areas, geological erosion has been great and only Lithosols or Regosols have developed. On some steep slopes, however, soils with developed horizons have formed.

The small areas of imperfect or poor drainage consist principally of swales or shallow basins underlain by basalt and occupied by Odin soils.

Time

In the different parts of the Area the soil-forming processes have worked on the parent materials for various lengths of time. Factors other than time have significantly affected the rate of soil development. In the nearly level parts of the northern half of the Area, the soil material has been acted on by climatic and biologic forces for a long time. In these regions soils that have a strongly developed or well developed subsoil or a caliche horizon have formed in the residuum of the Dalles or older formations. On slopes where dissection has been more rapid, the profile development is commonly weaker.

In the southern part of the Area, most of the soils are forming in a mantle of sandy pumice of Recent age that perhaps was laid down only 4,000 to 7,000 years ago (*16*). The profile development in these soils is weak where drainage is good to excessive. In the poorly drained swales and shallow basins, profile development is stronger. In these low areas, however, local material probably has been washed onto the soils.

Classification of Soils of the Area

In table 9 the soil series of the Deschutes Area are classified by soil orders and great soil groups, and some of the important factors that affect the development of the soils are given for each series.

Most of the soils are in the Brown great soil group. In places, the Lamonta, Agency, and Era soils have some characteristics of Chestnut soils. The Laidlaw soils lie in a climatic region similar to that of Chestnut soils, but Laidlaw soils probably can be best classified as Brown soils transitional to Brown Podzolic, as they have minimal profile development. They are also somewhat transitional to Regosols. In places, the Metolius soils are transitional to zonal soils.

The Deschutes, Redmond, and Odin series may be considered a catena of soils that formed principally in dacite pumice. The Deschutes series is well drained to somewhat excessively drained, the Redmond series is moderately well drained, and the Odin series is imperfectly to poorly drained.

Morphology of the Soils of the Area

In the following pages, the great soil groups that occur in the Area are described, and the morphology of soil series representative of each great soil group is discussed.

Brown soils

The soils of the Brown great soil group dominate in the Deschutes Area. Their surface soil is light brownish gray, grayish brown, pale brown, or brown. It is about neutral in reaction and fairly low in organic matter. In uncultivated areas that have little vegetation the ½- to 1-inch surface layer is vesicular, and the next 2 to 3 inches is platy. The subsoil is more alkaline than the surface soil and generally more compact or finer textured. It has a

TABLE 9.—*Soil series classified by higher categories and their principal soil-forming factors*

ZONAL

Great soil group and series	Precipitation	Natural vegetation	Parent material	Relief	Drainage	Horizon development
Brown soils:	*Inches*					
Agency	8.5 to 11	Big sagebrush, bunchgrasses, cheatgrass, rabbitbrush, and scattered junipers.	Weathered partly consolidated sandstones, agglomerates, and other fluvial materials, mainly of volcanic origin, including rhyolite, andesite, and basalt; small amount of fine windborne pumice, ash, and loess in upper part; weathered basaltic or other lava material in lower part.	Nearly level to hilly uplands.	Good	Moderate.
Deschutes	8 to 12	Big sagebrush, juniper, rabbitbrush, bunchgrasses, and cheatgrass.	Windborne dacite pumice; in lower part small amount of basaltic and gravelly and sandy materials from other sources; variable substratum.	Same	Good to somewhat excessive.	Weak.
Era	8.5 to 11	Big sagebrush, bunchgrasses, cheatgrass, rabbitbrush, and scattered junipers.	Weathered partly consolidated sandstones, agglomerates, and other fluvial materials, mainly of volcanic origin, including rhyolite, andesite, and basalt; small amount of fine windborne pumice, ash, and loess in upper part; weathered basaltic or other lava material in lower part.	Same	Good	Weak.
Lamonta	8.5 to 11	Same	Weathered partly consolidated sandstones, agglomerates, and other fluvial materials, mainly of volcanic origin, dominantly rhyolitic but includes andesitic and basaltic materials; small amount of windborne pumice, ash, and loess in upper part; in places, basalt substratum.	Nearly level to rolling uplands.	Good	Strong.
Madras	8.5 to 11	Same	Weathered partly consolidated sandstone, agglomerate, and other old fluvial materials, mainly of volcanic origin, including rhyolitic, andesitic, and basaltic materials.	Same	Good	Moderate.
Redmond	8 to 10	Big sagebrush, juniper, bunchgrasses, cheatgrass, and rabbitbrush.	Windborne dacite pumice and, in lower part, small amount of basaltic and gravelly or sandy materials.	Nearly level uplands; in places somewhat concave.	Moderately good.	Moderate.
Chestnut soil:						
Gem	11 to 12	Same	Weathered basalt	Undulating and rolling uplands.	Good	Moderate.
Chestnutlike or transitional between Brown and Brown Podzolic:						
Laidlaw	11 to 13	Big sagebrush, juniper, rabbitbrush, and bunchgrasses; in places some ponderosa pine and bitterbrush.	Windborne dacite pumice, in most places over a pumice flow.	Nearly level to rolling uplands.	Good to somewhat excessive.	Weak.

TABLE 9.—*Soil series classified by higher categories and their principal soil-forming factors*—Continued

INTRAZONAL

Great soil group and series	Precipitation	Natural vegetation	Parent material	Relief	Drainage	Horizon development
Low-Humic Gley: Odin	8 to 10	Grasses, big sagebrush, rabbitbrush; in places, sedges and reeds.	Windborne dacite pumice, probably mixed with or overlying weathered partly consolidated sandstone or other water-laid materials from nearby sources.	Depressions and small basins in uplands.	Imperfect to poor.	Medium.
AZONAL						
Alluvial soil: Metolius	8.5 to 11	Big sagebrush, bunchgrasses, cheatgrass, rabbitbrush, and scattered junipers.	Stratified sandy and loamy alluvium derived from dacite pumice and mixed volcanic materials.	Nearly level and gently undulating bottom lands and alluvial fans.	Good	Very weak.

horizon of lime accumulation below depths of 1.5 to 3 feet.

The Brown soils occur in areas that have a semiarid microthermal climate with an average annual precipitation between 8 and 11 inches and a natural vegetation dominated by big sagebrush, bunchgrasses, juniper, rabbitbrush, and cheatgrass.

AGENCY SERIES

In the Agency series are soils of the Brown great soil group that formed under a normal annual precipitation of 8.5 to 11 inches and a natural vegetation of big sagebrush, bunchgrasses, scattered junipers, and associated plants. These well-drained soils occur mainly in nearly level or gently undulating upland plains, and in some areas that are more dissected.

The upper part of Agency soils was derived principally from weathered, partly consolidated, sedimentary materials of the Dalles formation. These materials include pumiceous or tuffaceous sandstones, agglomerates, gravel, sands, tuffs, cinders, ashes, and agglomerate-mudflows (*5*). The water-spread materials are mostly volcanic. The sandstones and agglomerates dominate in the parent material. They are mixed and contain much rhyolitic and other acidic materials and materials that are andesitic and more basic. In some places the upper part of the soil contains a small admixture of fine pumice, volcanic ash, and loess. The lower parts of the soil typically are affected by or derived from weathered basaltic fragments which overlie basalt bedrock. The soils are moderately developed.

The following representative profile of Agency loam was observed on a north-facing slope of 5 percent in the northeastern part of the Agency Plains in the northeastern corner of sec. 26, T. 9 S., R. 13 E. The natural vegetation is dominated by big sagebrush, bunchgrasses, and cheatgrass.

A_1 0 to 7 inches, light brownish-gray to grayish-brown (10YR 5.5/2) light loam; weak very fine granular structure; when moist, very dark grayish brown (10YR 3/2) and very friable; pH 6.7 (bromthymol blue) at a depth of ½ inch, 7.0 at 5 inches; between shrubs thin fragile crust forms rough surface over ½ to 1 inch of vesicular material; when dry, vertical cracks form 5- or 6-sided plates 2 to 4 inches in diameter; next lower 2 or 3 inches is thin platy.

A_3 7 to 11 inches, loam slightly browner (10YR 5.5/2.5) than horizon above; when moist, dark grayish brown (10YR 4/2) and friable; pH 7.2 (bromthymol blue); moderately porous but otherwise similar to layer above.

B_{21} 11 to 15 inches, brown to pale-brown (10YR 5.5/3) light clay loam containing a few small stones of basalt; hard weak to moderate medium and fine subangular blocky structure; when moist, dark brown (10YR 4/3) and firm to friable; aggregates very thinly coated with slightly darker colloidal material; moderately porous; pH 7.6 (cresol red).

B_{22} 15 to 23 inches, brown (10YR 5/3) very hard clay loam containing a moderate number of angular fragments of basalt as much as 8 inches in diameter; moderate fine subangular blocky structure; when moist, dark yellowish brown (10YR 4/4) and firm; aggregates thinly coated with darker brown (7.5YR 4/3 moist) colloidal material; slightly to moderately porous; contains a few lighter colored krotovinas; pH 7.8 (cresol red).

C_{ca} 23 to 31 inches, principally fragments of basalt; small amount of interstitial material similar to material of the horizon above; lime in veins and as coatings; grades into basalt bedrock at a depth of about 31 inches.

The upper 16 inches of this soil apparently was derived mainly from pumiceous or tuffaceous sandstone. It contains a small quantity of very pale brown, light yellowish-brown, or yellow pumice the size of medium and fine sand. Probably small amounts of windborne fine pumice, volcanic ash, and loess have been added. The B_{22} horizon was derived from mixed residuum from sandstone and basalt. In places enough basalt fragments are on and in the surface soil to prevent tillage. The upper part of this soil commonly contains a few red rhyolitic and dark-colored basaltic and andesitic pebbles. These pebbles are rounded and subangular.

DESCHUTES SERIES

The Deschutes series consists of Brown soils that have formed in a climate and on relief similar to those in which the Agency soils have formed. The junipers on the Deschutes soils, however, are larger and more numerous than those on the Agency soils, and the bunchgrasses are sparser. Some of the junipers have a trunk 20 inches in diameter and a height of 30 feet. The higher water-holding capacity of the vesicular pumiceous material of the Deschutes soils possibly accounts for the more vigorous growth of the junipers.

The Deschutes soils differ from Agency soils in their parent material and degree of development. They were formed principally in dacite pumice sand, probably mixed with some finer volcanic dust. The lower part of the soils may be more or less mixed with fragments of basalt, pebbles, and other local alluvium from nearby ridges of Scabland, or with gravelly or sandy material from other sources. The pumice may have been deposited 4,000 to 7,000 years ago (*16*). The parent materials have been only slightly altered. A weakly developed profile has formed. A small amount of organic matter has accumulated in the surface soil.

The pumice was laid down on a basalt flow, probably of Recent age; on sandy and gravelly outwash fans, perhaps glacial outwash; on semicemented older gravelly and sandy materials; on volcanic cinders; and perhaps on other materials. The pumiceous material generally is deep enough to constitute the solum. Included in the Deschutes series are several soils having a solum similar to that of typical Deschutes soils but a substratum that differs widely.

Some of the coarser textured Deschutes soils are somewhat transitional to Regosols. In the extreme southern and western parts of the Area where the precipitation is higher and bitterbrush and ponderosa pine grow, some of the Deschutes soils differ somewhat from the typical soils of the series in being noncalcareous throughout, slightly less alkaline, and slightly darker in the surface soils. These soils are mapping inclusions. They somewhat resemble the Laidlaw soils.

The following is a representative profile of Deschutes sandy loam, observed about a mile southeast of Redmond in the SE¼SE¼ sec. 15, T. 15 S., R. 13 E. This soil occurs in nearly level areas or swales that lie about 5 feet lower than the adjacent ridges of Scabland. The natural vegetation is dominated by big sagebrush but includes considerable rabbitbrush, scattered junipers, and sparse bunchgrasses. Scattered basalt fragments are on and in this soil.

A_1 0 to 4 inches, light brownish-gray to pale-brown (10YR 6/2.5), soft sandy loam; mostly pumiceous material containing a moderate quantity of light yellowish-brown, very pale brown, or pale-yellow coarse sandy pumice and a little pumice the size of small pebbles. Structure of ½-inch surface layer is single grain to very weak very fine granular and, in lower part, vesicular; rest of layer is weak thin platy; top of plates is grayer and smoother than bottoms; when moist, dark grayish brown (10YR 4/2) and very friable; pH 6.6 (bromthymol blue) at depth of ⅛ inch; 6.7 at 3 inches.

A_3 4 to 13 inches, similar to layer above except slightly browner or yellower; single-grain to very weak very fine granular structure, and pH of 7.2 (bromthymol blue).

B_2 13 to 21 inches, light yellowish-brown (2.5Y 6/3) to pale-brown (10YR 6/3), hard heavy sandy loam; weak fine and medium subangular blocky structure; aggregates slightly dense to slightly porous, pumiceous, like layer above, but contains a little dark-colored material; pH 7.8 (cresol red); when moist, dark brown (10YR 4/3) to dark grayish brown (10YR 4/2) and olive brown (2.5Y 4/3) and firm to friable.

B_{3ca} 21 to 28 inches, similar to layer above but has few lime veins in places and a pH of 8.0 (cresol red); aggregates themselves slightly dense but, between aggregates, very porous and somewhat loose.

D 28 inches +, basalt bedrock; top and cracks coated with white lime.

ERA SERIES

In the Era series are soils of the Brown great soil group that developed from parent material similar to that of Agency soils and under the influence of similar climate and relief. The degree of profile development of Era soils, however, is weak instead of moderate. The Era subsoil is a sandy loam or loam instead of a clay loam. Several factors cause the weak profile development. In many places the dissection is greater or more recent than that of Agency soils and the slopes are steeper. In some areas the water-spread materials are recent. In other places the cause of the weak development is unknown. Era soils contain considerably less pumice than Deschutes soils and have a more friable subsoil.

The following description of Era sandy loam is representative of the series:

A_p 0 to 7 inches, light brownish-gray to grayish-brown (10YR 5.5/2) slightly hard sandy loam; contains a small amount of pumice sand and a moderate number of red angular and subangular rhyolitic pebbles less than an inch in diameter; single-grained to very weak very fine granular structure; when moist, very dark grayish brown (10YR 3/2), and very friable; pH 7.1 (bromthymol blue).

B_1 7 to 14 inches, slightly finer textured and slightly paler brown than layer above; mainly massive to single-grain structure; friable; pH 7.5.

B_2 14 to 23 inches, pale-brown to brown (10YR 5.5/3) heavy sandy loam or light loam; contains pebbles and pumice sand and a few small fragments like soil in layers above; weak subangular blocky to massive; when moist, dark grayish brown to dark brown (10YR 4/2.5) and friable; pH 7.8 (cresol red).

B_{3ca} 23 to 31 inches, similar to horizon above except that (1) it is slightly calcareous and has lime in segregations and as coatings on some pebbles and rock fragments; (2) it is slightly more distinct in structure; and (3) it contains more rock fragments.

31 inches +, basalt coated with lime.

LAMONTA SERIES

In the Lamonta series are soils of the Brown great soil group. They formed under conditions of climate, relief, and vegetation similar to those under which the Agency soils formed. The parent material of the soils of the two series was rather similar, but in places the Lamonta soils were derived to a greater extent from residuum from fragments of rhyolite. Instead of basalt, the Lamonta soils in most areas are underlain by partly consolidated agglomerates and sandstones of the Dalles formation or by old water-spread or colluvial material from nearby buttes.

Lamonta soils have a claypan subsoil that is finer textured and denser than the subsoil of Agency and Madras soils. This subsoil may result from parent material that is slightly different and finer textured than the parent material of Agency and Madras soils, or it may result from a more advanced stage of development. Because of higher precipitation and denser vegetation, some of the Lamonta soils near Haystack Butte are slightly darker than typical. These soils have some characteristics of Chestnut soils.

The following representative profile of Lamonta sandy clay loam was observed in a gently sloping upland plain about 3 miles southeast of Culver, about ⅛ mile from the base of a butte in the SE¼NW¼ sec. 27, T. 12 S., R. 13 E:

A_p 0 to 9 inches, grayish-brown (10YR 5/2) hard sandy clay loam containing a moderate number of angular and subangular red rhyolitic pebbles; moderate fine granular structure; when moist, very dark brown (10YR 2/2) and friable; slightly sticky and slightly plastic; pH 7.2 (bromthymol blue).

B_1 9 to 13 inches, grayish-brown to brown (10YR 4.5/2.5) hard heavy sandy clay loam containing pebbles similar to those in layer above; weak medium subangular blocky structure; aggregates very slightly coated with colloids; when moist, very dark grayish brown (10YR 2.5/2) and firm to friable; pH 7.4 (bromthymol blue).

B_2 13 to 26 inches, brown (10YR 4.5/3) very hard dense clay containing a moderate number of subangular and angular red rhyolitic pebbles and small cobblestones; strong fine and medium blocky or subangular blocky structure, very weakly or weakly prismatic; aggregates thickly coated with dark brown colloidal material; when moist, dark brown (10YR 4/3) and firm or very firm; sticky and plastic; pH 7.8 (cresol red); noncalcareous.

B_{31ca} 26 to 35 inches, very pale brown (10YR 7/4) friable hard light clay loam containing a few pebbles and cobblestones similar to those in layer above; weak very fine subangular blocky structure; moderately porous; highly calcareous, with splotches, veins, and coatings of white lime; pH 8.5 (thymol blue).

B_{32ca} 35 to 41 inches, similar to layer above but contains less lime and is more massive.

C_{ca} 41 inches +, weakly cemented or semiconsolidated sandstone or agglomerates; lime in seams and splotches.

MADRAS SERIES

The Madras soils belong to the Brown great soil group. They formed under climate and vegetation similar to those under which the Agency soils formed. Madras soils were derived mainly from residuum from the underlying Dalles formation, mainly partly consolidated pumiceous or tuffaceous sandstone and agglomerate. In places the upper part of the parent material has a small admixture of fine pumice, volcanic ash, and loess.

Unlike the Agency soils, the Madras soils typically have a lime-and-silica hardpan or caliche that overlies or is in a layer of somewhat consolidated sandstone and agglomerate. In places the hardpan is dense and several inches thick. It may be in the form of variously thick plates, which in places are fractured; or it may consist mainly of crusts or cemented thin coats of lime that are on or between the strata of the sedimentary materials or in cracks. In places the hardpan is not continuous. It is more strongly developed in the nearly level higher plains than in the more strongly sloping areas. Generally it is only weakly cemented where the slopes are stronger than 6 to 8 percent.

The typical Madras soil is moderately developed and has a clay loam B_2 horizon. It differs from the Lamonta soils, which have a clay B_2 horizon.

The following representative profile of Madras loam was observed in a pit that was dug in an area having a cover of much big sagebrush, considerable rabbitbrush and cheatgrass, and rather sparse bunchgrasses. The profile was in a level area in the upland plain northwest of Culver in the SE¼NW¼ sec. 12, T. 12 S., R. 12 E.

A_1 0 to 6 inches, grayish-brown to light brownish-gray (10YR 5.5/2) slightly hard to soft loam fine granular structure; contains small amount of medium and coarse sand pumice; and a few red subangular rhyolitic and dark angular vesicular basaltic pebbles as large as 1 inch in diameter; when moist, very dark grayish brown (10YR 3/2) and very friable; pH 6.7 (bromthymol blue) at a depth of ¼ inch, 6.7 at 3 inches; between shrubs, a thin, fragile, micro-rough surface crust overlies ½ inch of slightly vesicular material; structure of next 2½ inches is weak thin or medium platy; lower 3 inches is very thick platy; very many roots.

B_1 (or A_3) 6 to 10 inches, brown to pale-brown (10YR 5.5/3) slightly hard heavy loam or light clay loam containing pebbles like those in horizon above; weak fine granular to subangular blocky structure; when moist, dark grayish brown (10YR 4/2); pH 7.2 (bromthymol blue); many roots.

B_{21} 10 to 18 inches, pale-brown to brown (10YR 5.5/3) very hard clay loam; contains a little pumice sand; and a few rounded and subangular pebbles smaller than 2 inches in diameter; strong fine subangular blocky structure; aggregates coated with brown (10YR 5/3) colloidal material; when moist, firm and brown (10YR 5/3) with dark-brown (7.5YR 3/2) coating on aggregates; few to moderate number of fine pores; pH 7.9 (cresol red); moderate number of roots.

B_{22} 18 to 26 inches, light yellowish-brown (10YR 6/4) firm gravelly clay loam; contains many subangular and rounded pebbles and little pumice sand; moderate subangular fine blocky structure; aggregates coated with pale-brown (10YR 6/3) colloidal material; slightly porous; pH 8.2 (cresol red); moderate number of roots; lower 2 inches slightly calcareous.

C_{mca} 26 to 32 inches, light brownish-gray (10YR 5.5/2) indurated tuffaceous sandstone that can be broken with a spade; stratified or platy; pH 8.5 (cresol red); top part has a 0.1 inch coating of white and pinkish-white, smooth, glazed lime and perhaps siliceous material; bottom of layers micro-rough with stalactites.

D_r 32 inches+, semiconsolidated tuffaceous sandstone.

REDMOND SERIES

The Redmond series consists of Brown soils of the group that formed under climatic and biologic conditions similar to those under which the Deschutes soils formed. The parent material of the soils of the two series were somewhat similar but the pumice of Redmond soils has been mixed with more wash from nearby higher areas. In many places the lower part of Redmond soils was influenced by material weathered from basalt or partly consolidated tuffaceous or pumiceous sandstone. Typically, these soils lie in nearly level, level, or shallow swalelike or concave areas between ridges and mounds of Scabland, or in low areas among higher lying Deschutes soils. In most places, especially where irrigated, these soils are moderately well drained. Some runoff is received from the higher areas.

Redmond soils are in the Deschutes-Redmond-Odin catena, which is a group of soils developed principally in sandy pumice. Redmond soils differ from the weakly developed Deschutes soil in being moderately to moderately weakly developed and in having a B_2 horizon that is distinctly finer in texture and more compact. This development apparently results from the greater moisture and the slightly finer parent material. Redmond soils are better drained and browner than the Odin soils, and they differ from the Agency soils in being derived mainly from pumiceous material.

The following representative profile was observed under natural cover east of Prineville Junction in NE¼NE¼ sec. 25, T. 14 S., R. 13 E., in a nearly level, very shallow swale, ⅛ mile wide. This moderately well drained area has a cover of big sagebrush, junipers, some rabbitbrush and cheatgrass, and sparse bunchgrasses. The big sagebrush is 2 to 3 feet tall, and the plants are 2 to 4 feet apart. The junipers are as large as 20 inches in diameter and 25 feet tall; they are about 50 to 100 feet apart.

A_{11} 0 to ½ inch, light brownish-gray to grayish-brown (2.5Y 5.5/2) soft sandy loam; contains a moderate quantity of very pale brown, light yellowish-brown, or pale-yellow pumice the size of coarse, medium, and fine sand, a small quantity of pumice the size of very coarse sand, some dark-colored fine sand, and a little red fine sand; also contains a very few angular basalt fragments as large as 1 inch in diameter; very weak very fine granular structure; slightly vesicular and very porous beneath a very thin, fragile, surface crust; when moist, very dark grayish brown (10YR 3/2) and very friable; at depth of ⅛ inch pH 6.5 (bromthymol blue); under juniper trees and big sagebrush shrubs, pH about 6.2; pumice sand collects in miniature depressions on the surface and when dry colors the surface a pale brown or light yellowish brown.

A_{12} ½ to 4 inches, similar to layer above, but structure weak thin to medium platy, with top of plates smooth and grayish, and bottoms of plates pale brownish and rough; pH 6.9 (bromthymol blue).

A_3 4 to 9 inches, light olive-brown (2.5Y 5.5/3) to pale-brown or light brownish-gray (10YR 6/2.5) soft sandy loam; single-grain to very weak very fine granular structure; when moist, dark grayish brown (10YR 3.5/2); pH 7.5 (cresol red); not platy; otherwise similar to horizon above; many roots.

B_1 9 to 11 inches, light yellowish-brown (2.5Y 6/3) to pale-brown (10YR 6/3), slightly hard friable light gritty loam; contains pumice and coarse particles similar to those in horizons above; very weak fine and medium subangular blocky to rounded structure; when moist, dark grayish brown (10YR 3.5/2) and friable; moderate number of fine pores; pH 7.8 (cresol red); very few hard, rounded, slightly dense nodules of soil material; many roots.

B_2 11 to 20 inches, light yellowish-brown (2.5Y 6/3) hard to very hard heavy loam or light clay loam; contains pumice and coarse fragments of basalt like those in horizons above; moderate medium and fine subangular blocky structure; few fine pores; when moist, olive brown (2.5Y 4/3) to dark grayish brown or dark brown (10YR 4/2.5) and firm to friable; pH 8.0 (cresol red); numerous roots; channels coated with brown or dark-brown organic material; few to moderate number of rounded very hard and dense nodules of soil material less than 1 inch in diameter.

B_3 20 to 24 inches, light yellowish-brown to light brownish-gray (2.5Y 6/2.5) hard fine sandy loam; contains a small quantity of pumice sand and a few to moderate number of angular and subangular fragments of basalt as large as 1 inch in diameter; weak medium and fine subangular blocky structure; few to moderate number of fine pores; when moist, olive brown (2.5Y 4/3) to dark grayish brown (10YR 4/2); noncalcareous; pH 8.3 (thymol blue); few to moderate number of roots.

B_{3ca} 24 to 28 inches, similar to horizon above but somewhat calcareous, with lime coatings on lower sides of basalt fragments; pH 8.5.

D 28 inches +, basalt bedrock lime, coated on top and in cracks.

Chestnut soils

Soils of the Chestnut great soil group occupy a small part of the Area southeast and east of Haystack Butte. This region is higher than most of the Area and has more precipitation. In places the soils are on north-facing slopes. Consequently, there is more vegetation, particularly grasses. The soils have a dark and more granular surface soil than Brown soils, as well as a slightly greater depth to the horizon of lime accumulation.

GEM SERIES

Gem soils are well-drained Chestnut soils that formed in residuum from basalt in nearly level to rolling or somewhat hilly uplands. These soils formed under an annual precipitation of 11 or 12 inches. The cover was moderately abundant bunchgrasses, big sagebrush, rabbitbrush, juniper, bitterbrush, and associated herbs. The decaying roots of this vegetation, particularly the bunchgrasses, helped form soils with fairly dark granular surface soils of moderate organic matter content. The finer textured material helped to retain organic matter. Gem soils are moderately developed.

The following representative profile of Gem clay loam was observed in the NW¼NE¼ sec. 13, T. 13 S., R. 13 E:

A 0 to 8 inches, dark grayish-brown (10YR 4/2) hard to very hard clay loam; contains a few angular and subangular fragments of basalt smaller than 4 inches in diameter; when moist, very dark grayish brown (10YR 2.5/2) and firm; neutral to slightly acid; upper 3 inches strong to moderate fine granular structure; rest of layer moderately fine and medium granular; widely spaced vertical cracks.

B_2 8 to 23 inches, brown (10YR 4.5/3) heavy clay loam or clay of a very weak prismatic structure that breaks into dense very hard moderate medium subangular blocky aggregates; aggregates coated with glossy colloid darker than soil material; when moist, dark brown and firm to very firm; noncalcareous; mildly alkaline; contains fragments of basalt like that in horizon above.

B_{3ca} 23 to 28 inches, brown (10YR 5/3) very hard, firm, heavy clay loam containing rock fragments like in layer above; weak medium subangular blocky structure; aggregates glossy and coated with colloid but only faintly darker outside than inside; few large lime veins and splotches.

C_{ca} 28 to 38 inches, light yellowish-brown (10YR 6/4) very hard, heavy clay loam containing numerous basalt fragments; weak subangular blocky structure; moderate amount of lime in veins, on lower side of rock fragments and in splotches.

D 38 inches +, lime-coated fragments of basalt over basalt bedrock.

Chestnutlike or Brown soils transitional to Brown Podzolic

In the southern and southwestern parts of the Area where the normal annual precipitation is 11 to 12 inches or slightly more, the soils that developed differ from typical Chestnut soils. They are noncalcareous throughout, somewhat less dark, lower in organic matter, and less granular. These differences result partly from the coarse pumiceous parent material that has been deposited fairly recently. The little calcium carbonate that has formed has been leached from the sandy material. Less organic matter has formed because this coarse-textured soil with high water-holding capacity seems better suited to trees than to grasses. In this zone the sagebrush and juniper are mixed with ponderosa pine, which becomes thicker as the precipitation increases. Brown Podzolic soils have formed in this area of higher precipitation where the pine is thicker.

The soils in this transitional zone perhaps can best be classified as Brown-Brown Podzolic transitional soils. They have very weak profile development, and therefore are somewhat transitional to Regosols. A few soils mapped in the Deschutes series have characteristics similar to those of this group.

LAIDLAW SERIES

The Laidlaw soils are transitional between Brown soils and Brown Podzolic soils. They have formed in 2 or 3 feet of windborne pumice sand that was deposited on a pumice flow several feet deep. The pumice apparently is a dacite. This dacite contained or was mixed with small crystals of plagioclase and hypersthene, smaller quantities of augite and hornblende, and some fragments of basalt and andesite. The Laidlaw soils differ from the Deschutes soils mainly in being entirely noncalcareous, somewhat darker, and slightly higher in organic matter.

The following representative profile of Laidlaw sandy loam was observed in the rolling uplands southwest of Tumalo, on an undulating ridge in the SE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 36, T. 16 S., R. 11 E. The natural vegetation consisted of a moderate growth of big sagebrush, widely spaced junipers, some rabbitbrush, and rather sparse bunchgrasses.

0 to 7 inches, grayish-brown (10YR 5/2) soft light sandy loam; contains much pumice the size of medium and coarse sand, a moderate quantity of pumice the size of very coarse sand, small pebbles of pumice as large as $\frac{3}{16}$ inch in diameter, a very few pebbles of pumice $\frac{3}{16}$ to 1 inch in diameter, and a few subangular pebbles of basalt or andesite as large as 1 inch in diameter; single grain; when moist, very dark grayish brown (10YR 3/2) and very friable; pH 6.4 (bromthymol blue); between shrubs, a very thin fragile surface crust overlies 3 inches of material that is slightly coarse and slightly platy; here pumice particles are light yellowish brown, very pale brown, or pale yellow.

7 to 17 inches, similar to layer above but slightly browner and not platy; very many roots.

17 to 23 inches, pale-brown (10YR 6/3) hard to slightly hard light sandy loam containing pumice and pebbles like those in layer above; weak to very weak medium rounded and subangular blocky structure; when moist, dark grayish brown (10YR 4/2) and friable to firm; noncalcareous; pH 6.9 (bromthymol blue); very many roots.

23 to 30 inches, pale-brown (10YR 6/3) soft, very friable, gravelly loamy sand made up mostly of pumice; contains many rounded and subangular pebbles of pumice as large as 1.5 inches in diameter, and few fragments of pumice as large as 4 inches in diameter; single grain; noncalcareous; many roots; pH 7.6 (cresol red).

30 to 80 inches, light-gray, splotched with yellowish brown, noncalcareous pumice-flow material; consists mostly of fine sandy interstitial pumiceous material among rounded to angular pebbles and lumps of pumice as large as 10 inches in diameter; contains some dark basic rock fragments the size of sand and small pebbles, pumice is light in weight and very vesicular; in most places this material is capped by an indurated layer about $\frac{1}{20}$ inch thick; layer apparently cemented by siliceous material; pick or heavy bar needed to break layer; next few inches are weakly to strongly cemented.

Low-Humic Gley soils

The Low-Humic Gley soils have been more affected by depressed relief and imperfect drainage than by climate and vegetation. Gleyed horizons have formed and mottles are common. The lime has been leached from the soil, and not much organic matter has accumulated.

ODIN SERIES

The Odin soils are imperfectly to poorly drained Low-Humic Gleys. They lie in depressions and small basins that generally have no natural outlets. Most of these areas receive runoff from surrounding higher soils. Particularly in irrigated sections, at least a moderately high water table occurs part of the time, and a few areas are flooded for short periods. The poor drainage of some of the areas is probably caused by long periods of irrigation. The natural vegetation probably consisted of bunchgrasses, big sagebrush, rabbitbrush, and junipers, but some areas now have water-loving grasses, sedges, and reeds, and a few places have cattails. The annual precipitation ranges from 8 to 10 inches.

Odin soils are the poorest drained soils of the Deschutes-Redmond-Odin catena, the soils of which formed principally in dacite pumice. In some places, however, the parent material of Odin soils contains local wash. In other places the lower part of the soil was derived from or affected by the underlying partly consolidated sandstone, other water-laid materials, or basalt. The parent material is mixed, but it is mostly acid and igneous. The soils differ from Redmond soils in being more poorly drained, grayer, mottled, and noncalcareous in most places. In many places a weakly cemented layer occurs in the lower part of the Odin soils. This layer appears to be a geologic stratum of the Dalles formation.

The following representative profile of Odin sandy loam was observed southeast of Terrebonne in the NE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 26, T. 14 S., R. 13 E. The site is in a slightly depressed area that is surrounded by Redmond sandy loam and Scabland. The vegetation includes sedges and water-loving grasses, and cattails grow in intermittent ponds in the lowest parts of the site. The entire profile is noncalcareous.

1 to 0 inch, partly decomposed roots and stems of grasses and sedges; pH 6.2.

0 to 3 inches, light-gray heavy sandy loam (2.5Y 7/1) with very few mottles of light yellowish brown (2.5Y 6/4); contains much medium and coarse pumice sand; single grain; when moist, friable and dark gray (2.5Y 4/1), with a very few light olive-brown mottles; pH 6.5 (bromthymol blue); very many roots.

3 to 11 inches, mottled, friable to very friable heavy sandy loam containing pumiceous material like that in layer above; massive to single grain; when moist, dark gray (2.5Y 4/1) mottled with dark brown (7.5YR 4/3) and dark grayish brown (10YR 3.5/2); pH 6.7 (bromthymol blue).

11 to 20 inches, mottled, firm to friable, moderately porous, light sandy clay loam; contains pumice like that in layer above; moderate medium subangular blocky structure; contains some rounded, firm nodules of soil material $\frac{1}{2}$ inch in diameter; when moist, dark grayish brown (10YR 4/2.5) mottled with dark gray (2.5Y 4/1); black or very dark gray stains of iron and manganese on many aggregates; pH 6.8 (bromthymol blue); moderate number of roots.

20 to 37 inches, firm clay loam containing a little pumice sand and a very few cobblestones; moderate to strong fine subangular blocky structure; when moist, dark grayish brown (10YR 4/2) with a few dark-gray mottles and a few dark stains of iron and manganese on aggregates; contains very hard, small, rounded concretions as large as $\frac{1}{16}$ inch in diameter; pH 6.9 (bromthymol blue); few roots.

37 to 45 inches, firm, softly cemented sandstone consisting mostly of light-colored materials but containing considerable reddish and dark sand; when moist, dark grayish brown to dark brown (10YR 4/2.5), with a few mottles of darker brown; pH 7.6 (cresol red).

45 to 53 inches, similar to layer above but not mottled.

53 to 60 inches, dark grayish brown (10YR 4/2 when moist) very friable, sandy loam with pockets of dark-brown (7.5YR 4/3) friable clay loam; massive; pH 7.6 (cresol red).

Alluvial soils

Alluvial soils are forming in fairly recent alluvium. These soils do not have a well-developed profile, although some characteristics of the zonal soils may be very weakly expressed. Alluvial soils resemble zonal soils in color of the surface soils, but they have no, or only very weak, textural and structural development, and they have no, or only a weak, horizon of lime accumulation.

METOLIUS SERIES

The Metolius soils are Alluvial soils that are associated with the Brown soils. In places they are somewhat transitional to the Brown soils. The well-drained Metolius soils lie in nearly level to very gently undulating bottom lands of intermittent streams in elongated swales, in plains, and on sloping alluvial fans. They are forming in somewhat stratified sandy and loamy alluvium. This alluvium contains a large quantity of light-colored pumice sand mixed with material from basalt, andesite, and rhyolite. Possibly some of the material was deposited from the air as fine pumice, volcanic ash, or loess. The annual precipitation ranges from 8 to 10 inches. Big sagebrush and bunchgrasses dominate.

The following representative profile of Metolius sandy loam was observed on the nearly level flood plains of the intermittent Mud Spring Creek southeast of Paxton in the SE¼SW¼ sec. 17, T. 10 S., R. 14 E. The pit was dug in a dry-farmed wheatfield. The soil is generally well drained; it is infrequently flooded. The annual precipitation is about 9 inches.

A_p 0 to 6 inches, light brownish-gray to grayish-brown (10YR 5.5/2) slightly hard heavy sandy loam; contains much medium, fine, and coarse pumice sand mixed with sand from other lavas; single-grain to very weak very fine granular structure; when moist, very dark grayish brown (10YR 3.5/2) and very friable; noncalcareous; pH 7.8 (cresol red).

C_{11} 6 to 14 inches, light brownish-gray to pale-brown (10YR 6/2.5) soft moderately porous sandy loam containing pumice and other materials like those in horizon above; single grain; when moist, dark grayish brown (10YR 4/2) and very friable; noncalcareous; pH 7.8 (cresol red).

C_{12} 14 to 22 inches, similar to horizon above in color; very friable heavy sandy loam containing a few firm, dense, rounded to elongated nodules as long as 1 inch; single grain to very weak medium and coarse subangular blocky structure; moderately porous; noncalcareous; pH 8.2 (cresol red).

C_{13} 22 to 29 inches, similar to horizon above in color; very friable light sandy loam containing pumice and other material like those in surface horizon; single-grain structure; slightly calcareous, with the lime disseminated; pH 8.2 (cresol red).

C_{21} 29 to 38 inches, light-gray (10YR 7/1.5) soft very porous loamy sand; single grain; when moist, light olive-brown (2.5Y 5/3) and very friable; slightly calcareous; pH 8.6 (cresol red); much pumice the size of medium and coarse sand.

C_{22} 38 to 46 inches, light brownish-gray (10YR 6/2) soft very porous light sandy loam; single grain; when moist, dark grayish brown (10YR 4/2) and very friable; noncalcareous or slightly calcareous; pH 8.4.

C_{23} 46 to 49 inches +, light brownish-gray (10YR 6/2) loose gravelly sand; single grain; moderately calcareous, the pebbles slightly lime-coated; contains a little pumice.

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SOILS OF THE DESCHUTES AREA, OREGON:

Soil or land type	Map symbol	Soil Profile			Depth [1]
		Surface soil	Subsoil	Underlying material	*(Feet)*
Agency gravelly loam, 0 to 3 percent slopes.	Aa	Light brownish-gray to grayish-brown noncalcareous gravelly loam; very dark grayish brown when moist.	Brown gravelly clay loam; breaks into subangular blocky aggregates; noncalcareous except in lower part.	Lime-coated rock fragments over basalt bedrock.	1.5 to 3
Agency gravelly loam, 3 to 7 percent slopes.	Ab	Same	Same	Same	1.5 to 3
Agency gravelly loam, 7 to 12 percent slopes.	Ad	Same	Same	Same	1.5 to 2.5
Agency gravelly loam, eroded, 3 to 7 percent slopes.	Ac	Same	Same	Same	1.3 to 2.7
Agency gravelly loam, eroded, 7 to 12 percent slopes.	Ae	Same	Same	Same	1.3 to 2.2
Agency loam, 0 to 3 percent slopes	Af	Light brownish-gray to grayish-brown, noncalcareous, slightly hard loam; very fine granular structure; when moist, very dark grayish brown.	Brown, hard clay loam grading to pale brown or light yellowish brown in the lower part; subangular blocky structure; noncalcareous except in lower part.	Same	1.7 to 3
Agency loam, 3 to 7 percent slopes	Ah	Same	Same	Same	1.7 to 3
Agency loam, 7 to 12 percent slopes	Al	Same	Same	Same	1.5 to 2.5
Agency loam, 12 to 20 percent slopes.	Am	Same	Same	Same	1.5 to 2.5
Agency loam, eroded, 0 to 3 percent slopes.	Ag	Same	Same	Same	1.5 to 2.8
Agency loam, eroded, 3 to 7 percent slopes.	Ak	Same	Same	Same	1.5 to 2.8
Agency loam, eroded, 20 to 35 percent slopes.	An	Same	Same	Same	1.3 to 2.2
Agency loam, stony, 0 to 3 percent slopes.	Ao	Light brownish-gray to grayish-brown, noncalcareous, slightly hard stony loam; very fine granular structure; when moist, very dark grayish brown.	Brown, hard stony clay loam grading to pale brown or light yellowish brown in lower part; subangular blocky structure; noncalcareous except in lower part.	Same	1.7 to 3
Agency loam, stony, 3 to 7 percent slopes.	Ap	Same	Same	Same	1.6 to 2.8
Agency loam, stony, 7 to 12 percent slopes.	Ar	Same	Same	Same	1.5 to 2.5
Agency loam, stony, 12 to 20 percent slopes.	As	Same	Same	Same	1.5 to 2.5
Agency loam, stony, 20 to 35 percent slopes.	At	Same	Same	Same	1.1 to 2.2
Agency sandy loam, 0 to 3 percent slopes.	Au	Light brownish-gray to grayish-brown noncalcareous sandy loam; very dark grayish brown when moist.	Brown, hard sandy clay loam grading to pale brown or light yellowish brown in the lower part; subangular blocky structure; noncalcareous except in lower part.	Same	1.7 to 3
Agency sandy loam, 3 to 7 percent slopes.	Aw	Same	Same	Same	1.7 to 3
Agency sandy loam, eroded, 0 to 3 percent slopes.	Av	Same	Same	Same	1.5 to 2.8
Agency sandy loam, eroded, 3 to 7 percent slopes.	Ax	Same	Same	Same	1.5 to 2.8

See footnotes at end of table.

SUMMARY OF IMPORTANT CHARACTERISTICS

Water-holding capacity [2]	Drainage through the soil [3]			Erosion hazard under irrigation	Natural fertility [4]	Ease of irrigation [5]	Workability [6]	Principal use
	Surface soil	Subsoil	Underlying material					
Moderate to somewhat low.	Moderate	Moderate	Very slow; in places, slow or none.	Slight	Moderate	Very easy	Good	Dry-farmed wheat; range.
Same	Moderate	Moderate	Same	Moderate	Moderate	Slightly difficult.	Good	Range; dry-farmed wheat.
Same	Moderate	Moderate	Same	High	Moderate	Difficult	Fair	Range; dry-farmed wheat.
Same	Moderate	Moderate	Same	Moderate	Moderate to low.	Slightly difficult.	Good	Range; dry-farmed wheat.
Same	Moderate	Moderate	Same	High	Same	Difficult	Fair	Range; dry-farmed wheat.
Moderate to somewhat high.	Moderate	Moderate	Same	Slight	Moderate	Very easy	Very good	Dry-farmed wheat.
Same	Moderate	Moderate	Same	Moderate	Moderate	Slightly difficult.	Very good	Range; dry-farmed wheat.
Same	Moderate	Moderate	Same	High	Moderate	Difficult	Good	Range.
Same	Moderate	Moderate	Same	Very high	Moderate	Very difficult.	Fair	Range; dry-farmed wheat.
Same	Moderate	Moderate	Same	Slight	Moderate	Very easy	Very good	Dry-farmed wheat.
Same	Moderate	Moderate	Same	Moderate	Moderate	Slightly difficult.	Very good	Range; dry-farmed wheat.
Moderate to low.	Moderate	Moderate	Same	Very high	Moderate to low.	Very difficult.	Poor	Range.
Moderate	Moderate	Moderate	Same	Slight	Moderate	Easy	Very poor	Range.
Moderate	Moderate	Moderate	Same	Moderate	Moderate	Slightly difficult.	Very poor	Range.
Moderate	Moderate	Moderate	Same	High	Moderate	Difficult	Very poor	Range.
Moderate	Moderate	Moderate	Same	Very high	Moderate	Very difficult.	Very poor	Range.
Moderate to low.	Moderate	Moderate	Same	Very high	Moderate to low.	Very difficult.	Very poor	Range.
Moderate	Moderate to somewhat rapid.	Moderate	Same	Slight	Moderate	Very easy	Very good	Dry-farmed wheat; range.
Moderate	Same	Moderate	Same	Moderate	Moderate	Slightly difficult.	Very good	Dry-farmed wheat; range.
Moderate	Same	Moderate	Same	Slight	Moderate	Very easy	Very good	Dry-farmed wheat.
Moderate	Same	Moderate	Same	Moderate	Moderate	Slightly difficult.	Good	Dry-farmed wheat; range.

SOILS OF THE DESCHUTES AREA, OREGON:

Soil or land type	Map symbol	Soil Profile			Depth [1]
		Surface soil	Subsoil	Underlying material	(*Feet*)
Deschutes coarse sandy loam, over sandy material, 0 to 3 percent slopes.	Da	Grayish-brown to dark grayish-brown, noncalcareous, soft coarse sandy loam; single grain; when moist, very dark grayish brown; neutral reaction; slightly gravelly.	Grayish-brown to brown, very porous, very friable coarse sandy loam; single grain; slightly firmer in lower part; noncalcareous; neutral reaction	Gray and dark-gray, loose gravelly sand or coarse sand; single grain; noncalcareous.	1.7 to 3
Deschutes loam, stony, 0 to 3 percent slopes.	Db	Light brownish-gray to grayish-brown, noncalcareous, slightly hard light loam containing much pumice; stony.	Pale-brown or light yellowish-brown loam; weak subangular blocky aggregates; noncalcareous except in lower part.	Basalt bedrock, thinly coated with lime.	1.7 to 3
Deschutes loamy coarse sand, over gravelly material, 0 to 3 percent slopes.	Dc	Brown or grayish-brown, soft, noncalcareous loamy coarse sand; some pebbles; mostly pumice.	Brown or grayish-brown to pale-brown, slightly hard or soft, noncalcareous coarse sandy loam or loamy sand.	Noncalcareous somewhat loose gravelly loamy sand.	1.7 to 3
Deschutes loamy coarse sand, over gravelly material, 3 to 7 percent slopes.	Dd	Same	Same	Same	1.7 to 3
Deschutes loamy sand, 0 to 3 percent slopes.	De	Grayish-brown or light brownish-gray loamy sand grading to brown or pale brown; soft or very friable; single grain; noncalcareous; mostly pumice; when moist, dark grayish brown or very dark grayish brown.	Grayish-brown or light brownish-gray slightly hard loamy sand or sandy loam grading to brown or pale brown; weak subangular blocky structure; slightly calcareous in lower part; mostly pumice.	Basalt bedrock or cemented sedimentary material; top commonly coated with lime.	1.4 to 3
Deschutes loamy sand, 3 to 7 percent slopes.	Dg	Same	Same	Same	1.4 to 3
Deschutes loamy sand, 7 to 12 percent slopes.	Dh	Same	Same	Same	1.4 to 3
Deschutes loamy sand, eroded, 0 to 3 percent slopes.	Df	Same	Same	Same	1.3 to 2.9
Deschutes loamy sand, over cinders, 0 to 3 percent slopes.	Dk	Same	Same	Volcanic cinders, generally loose and porous.	1.4 to 3
Deschutes loamy sand, over cinders, 3 to 7 percent slopes.	Dl	Same	Same	Same	1.4 to 3
Deschutes loamy sand, over cinders, eroded, 3 to 7 percent slopes.	Dm	Same	Same	Same	1.3 to 2.9
Deschutes loamy sand, over cobbly material, 0 to 3 percent slopes.	Dn	Grayish-brown or light brownish-gray loamy sand grading to brown or pale brown; soft or very friable; single grain; noncalcareous; mostly pumice; contains some pebbles; when moist, dark grayish brown or very dark grayish brown.	Grayish-brown or light brownish-gray, slightly hard loamy sand or sandy loam grading to brown or pale brown; weak subangular blocky structure; slightly calcareous in lower part; mostly pumice; contains some pebbles and cobblestones.	Loose gravel, cobblestones, and few boulders.	1.5 to 3

See footnotes at end of table.

SUMMARY OF IMPORTANT CHARACTERISTICS—Continued

Water-holding capacity[2]	Drainage through the soil[3]			Erosion hazard under irrigation	Natural fertility[4]	Ease of irrigation[5]	Workability[6]	Principal use
	Surface soil	Subsoil	Underlying material					
Low	Somewhat rapid.	Somewhat rapid.	Very rapid	Slight	Moderate to low.	Very easy to easy.	Excellent	Irrigated hay, grain, alsike clover and vetch seed, and potatoes.
Moderate to somewhat high.	Moderate	Moderate	Very slow; in places, slow or none.	Slight	Moderate	Very easy	Fair	Range; irrigated pasture and hay.
Low	Rapid	Rapid	Very rapid to rapid.	Slight	Low	Easy to slightly difficult.	Excellent	Range; irrigated crops and pasture.
Low	Rapid	Rapid	Same	Moderate	Low	Slightly difficult.	Excellent	Range; irrigated crops and pasture.
Low	Rapid	Rapid	Very slow; in places, slow or none.	Slight	Low	Easy to slightly difficult.	Very good	Irrigated crops and pasture; range; some forest.
Low	Rapid	Rapid	Same	Moderate to somewhat high.	Low	Slightly difficult.	Very good	Same.
Low	Rapid	Rapid	Same	High	Low	Difficult	Good	Range; irrigated hay and pasture.
Low	Rapid	Rapid	Same	Slight	Low	Easy to slightly difficult.	Very good	Range.
Low	Rapid	Rapid	Generally very rapid.	Slight	Low	Same	Very good	Irrigated crops and pastures; range.
Low	Rapid	Rapid	Same	Moderate to somewhat high.	Low	Slightly difficult.	Very good	Range; irrigated crops and pasture.
Low	Rapid	Rapid	Same	Same	Low	Same	Very good	Irrigated crops and pasture.
Low	Rapid	Rapid	Very rapid	Slight	Low	Easy to slightly difficult.	Very good	Irrigated crops and pasture; gravel pits.

SOILS OF THE DESCHUTES AREA, OREGON:

Soil or land type	Map symbol	Soil Profile			Depth[1]
		Surface soil	Subsoil	Underlying material	
					(*Feet*)
Deschutes loamy sand, over gravelly material, 0 to 3 percent slopes.	Do	Grayish-brown or light brownish-gray loamy sand grading to brown or pale brown; soft or very friable; single grain; noncalcareous; mostly pumice; contains a few pebbles; when moist, dark grayish brown or very dark grayish brown.	Grayish-brown or light brownish-gray, slightly hard loamy sand or sandy loam grading to brown or pale brown; weak subangular blocky structure; slightly calcareous in lower part; in places, noncalcareous; mostly pumice; contains some gravel.	Nearly loose or very friable gravelly cobbly sandy loam or loamy sand.	2 to 3.5
Deschutes loamy sand, over gravelly material, 3 to 7 percent slopes.	Dp	Same	Same	Same	1.5 to 3
Deschutes loamy sand, over semicemented sandy material, 0 to 3 percent slopes.	Dr	Same	Same	Weakly to strongly cemented sandy material, mixed in many places with gravel and cobblestones; mostly highly calcareous; over sand or sand, gravel, and cobblestones.	2 to 3
Deschutes loamy sand, over semicemented sandy material, 3 to 7 percent slopes.	Ds	Same	Same	Same	2 to 3
Deschutes loamy sand, over semicemented sandy material, 7 to 12 percent slopes.	Dt	Same	Same	Same	1.5 to 3
Deschutes sandy loam, 0 to 3 percent slopes.	Du	Grayish-brown or light brownish-gray to brown or pale-brown, soft or very friable sandy loam; noncalcareous; mostly pumice.	Pale-brown or light yellowish-brown, hard or firm sandy loam; weak subangular blocky structure; slightly calcareous in lower part; mostly pumice.	Basalt bedrock or cemented sedimentary material; commonly coated with lime on top.	1.4 to 3
Deschutes sandy loam, 3 to 7 percent slopes.	Dv	Same	Same	Same	1.4 to 3
Deschutes sandy loam, 7 to 12 percent slopes.	Dw	Same	Same	Same	1.4 to 3
Deschutes sandy loam, 12 to 20 percent slopes.	Dy	Same	Same	Same	1.4 to 3
Deschutes sandy loam, deep, 0 to 3 percent slopes.	Dz	Same	Same	Same	3 to 5
Deschutes sandy loam, deep, 3 to 7 percent slopes.	Dea	Same	Same	Same	3 to 5
Deschutes sandy loam, deep over cinders, 0 to 3 percent slopes.	Deb	Same	Same	Volcanic cinders or pumicy material; generally loose and porous.	3 to 5
Deschutes sandy loam, eroded, 7 to 12 percent slopes.	Dx	Same	Same	Basalt bedrock or cemented sedimentary material; commonly coated with lime on top.	1.4 to 3
Deschutes sandy loam, over cinders, 0 to 3 percent slopes.	Dec	Same	Same	Volcanic cinders or pumicy material; generally loose and porous.	1.3 to 3
Deschutes sandy loam, over cinders, 3 to 7 percent slopes.	Ded	Same	Same	Same	1.3 to 3
Deschutes sandy loam, over cinders, eroded, 3 to 7 percent slopes.	Def	Same	Same	Same	1.3 to 3

See footnotes at end of table.

SUMMARY OF IMPORTANT CHARACTERISTICS—Continued

Water-holding capacity [2]	Drainage through the soil [3]			Erosion hazard under irrigation	Natural fertility [4]	Ease of irrigation [5]	Workability [6]	Principal use
	Surface soil	Subsoil	Underlying material					
Low	Rapid	Rapid	Rapid	Slight	Low	Same	Very good	Irrigated crops and pasture; range; dry-farmed rye.
Low	Rapid	Rapid	Rapid	Moderate to somewhat high.	Low	Slightly difficult.	Very good	Range; irrigated crops and pasture.
Low	Rapid	Rapid	Slow through the cemented layer; very rapid below.	Slight	Low	Easy to slightly difficult.	Very good	Range; irrigated crops and pasture.
Low	Rapid	Rapid	Same	Moderate to somewhat high.	Low	Slightly difficult.	Very good	Range; irrigated crops and pasture.
Low	Rapid	Rapid	Very rapid	High	Low	Difficult	Good	Range.
Moderate	Moderate to rapid.	Moderate to rapid.	Very slow; in places, slow or none.	Slight	Moderate	Very easy to easy.	Very good	Irrigated crops and pasture; some range.
Moderate	Same	Same	Same	Moderate	Moderate	Slightly difficult.	Very good	Same.
Moderate	Same	Same	Same	High	Moderate	Difficult	Good	Range; irrigated hay and pasture.
Moderate	Same	Same	Same	Very high	Moderate	Very difficult.	Fair	Range.
High	Same	Same	Same	Slight to negligible.	Moderate	Very easy to easy.	Very good	Irrigated crops and pasture.
High	Same	Same	Same	Moderate	Moderate	Slightly difficult.	Very good	Irrigated crops and pasture.
High to moderate.	Same	Same	Generally rapid.	Slight to negligible.	Moderate	Very easy to easy.	Very good	Irrigated crops and pasture.
Moderate	Same	Same	Very slow; in places, slow or none.	High	Moderate	Difficult	Good	Range; irrigated crops and pasture.
Moderate	Same	Same	Generally rapid.	Slight	Moderate	Very easy to easy.	Very good	Irrigated crops and pasture.
Moderate	Same	Same	Same	Moderate	Moderate	Slightly difficult.	Very good	Irrigated crops and pasture; range.
Moderate to low.	Same	Same	Same	Moderate	Moderate to low.	Same	Very good	Irrigated crops and pasture.

SOILS OF THE DESCHUTES AREA, OREGON:

Soil or land type	Map symbol	Soil Profile			Depth [1]
		Surface soil	Subsoil	Underlying material	(Feet)
Deschutes sandy loam, over semicemented sandy material, 0 to 3 percent slopes.	Deo	Light brownish-gray or grayish-brown, soft or very friable sandy loam; noncalcareous; mostly pumice.	Pale-brown or light yellowish-brown, hard or firm sandy loam; weak subangular blocky structure; slightly calcareous in lower part; mostly pumice; contains some pebbles.	Weakly to strongly cemented sandy material, mixed in many places with gravel and cobblestones; mostly highly calcareous; over sand or sand, gravel, and cobblestones.	2 to 3
Deschutes sandy loam, over semicemented sandy material, 3 to 7 percent slopes.	Des	Same	Same	Same	2 to 3
Deschutes sandy loam, over semicemented sandy material, 7 to 12 percent slopes.	Dla	Same	Same	Same	2 to 3
Deschutes sandy loam, over semicemented sandy material, eroded, 12 to 20 percent slopes.	Dlb	Same	Same	Same	1.5 to 3
Deschutes sandy loam, shallow, 0 to 3 percent slopes.	Dlc	Same	Pale-brown or light yellowish-brown, hard or firm sandy loam; slightly calcareous in lower part; mostly pumice; few rock fragments.	Basalt bedrock or cemented sedimentary material; commonly coated with lime on top or in cracks.	0.7 to 1.3
Deschutes sandy loam, shallow, 3 to 7 percent slopes.	Dle	Same	Same	Same	0.7 to 1.3
Deschutes sandy loam, shallow over cinders, 0 to 3 percent slopes.	Dlo	Same	Same	Volcanic cinders or pumicy material; generally loose and porous.	0.7 to 1.3
Deschutes sandy loam, shallow over cinders, eroded, 3 to 7 percent slopes.	Dls	Same	Same	Same	0.7 to 1.3
Deschutes sandy loam, stony, 0 to 3 percent slopes.	Dsa	Light brownish-gray or grayish-brown, soft or very friable stony sandy loam; noncalcareous; mostly pumice.	Pale-brown or light yellowish-brown, hard or firm stony sandy loam; slightly calcareous in lower part; mostly pumice; few rock fragments.	Basalt bedrock or cemented sedimentary material; commonly coated with lime on top.	1.4 to 3
Deschutes sandy loam, stony, 3 to 7 percent slopes.	Dsb	Same	Same	Same	1.4 to 3
Deschutes sandy loam, stony, 7 to 12 percent slopes.	Dsc	Same	Same	Same	1.4 to 3
Deschutes sandy loam, stony, over cinders, 3 to 7 percent slopes.	Dsd	Same	Same	Volcanic cinders or pumicy material; generally loose and porous.	1.4 to 3
Deschutes sandy loam, stony, over semicemented sandy material, 0 to 3 percent slopes.	Dse	Same	Same	Weakly to strongly cemented sandy material, mixed in many places with gravel and cobblestones; mostly highly calcareous; over sand or sand, gravel, and cobblestones.	2 to 3
Deschutes sandy loam, stony, over semicemented sandy material, 3 to 7 percent slopes.	Dsl	Same	Same	Same	2 to 3
Deschutes sandy loam, stony, over semicemented sandy material, 7 to 12 percent slopes.	Dso	Same	Same	Same	2 to 3

See footnotes at end of table.

SUMMARY OF IMPORTANT CHARACTERISTICS—Continued

Water-holding capacity [2]	Drainage through the soil [3]			Erosion hazard under irrigation	Natural fertility [4]	Ease of irrigation [5]	Workability [6]	Principal use
	Surface soil	Subsoil	Underlying material					
Moderate	Moderate to somewhat rapid.	Moderate to somewhat rapid.	Slow through the cemented layer; very rapid below.	Slight to negligible.	Moderate	Very easy to easy.	Very good	Irrigated crops and pasture; range.
Moderate	Same	Same	Same	Moderate	Moderate	Slightly difficult.	Very good	Range; irrigated crops and pasture.
Moderate	Same	Same	Same	High	Moderate	Difficult	Good	Range; irrigated hay and pasture.
Moderate to low.	Same	Same	Same	Very high	Moderate to low.	Very difficult.	Fair	Range; irrigated hay and pasture.
Low	Same	Same	Very slow; in places, slow or none.	Slight to negligible.	Low	Slightly difficult.	Very good	Range; irrigated pasture and hay.
Low	Same	Same	Same	Moderate	Low	Difficult	Good	Range; irrigated pasture and hay.
Low to very low.	Same	Same	Generally rapid.	Slight to negligible.	Low	Difficult	Very good	Range; irrigated pasture and hay.
Same	Same	Same	Same	Moderate	Low	Difficult	Good	Range; irrigated pasture and hay.
Moderate	Same	Same	Very slow; in places, slow or none.	Slight	Moderate	Easy	Fair or poor.	Range; irrigated pasture and hay.
Moderate	Same	Same	Same	Moderate	Moderate	Slightly difficult.	Fair to poor.	Range; irrigated pasture and hay.
Moderate	Same	Same	Same	High	Moderate	Difficult	Fair or poor.	Range; irrigated pasture and hay.
Moderate	Same	Same	Generally rapid.	Moderate	Moderate	Slightly difficult.	Fair or poor.	Range; irrigated pasture and hay.
Moderate	Same	Same	Slow through the cemented layer; very rapid below.	Slight	Moderate	Easy	Fair or poor.	Range.
Moderate	Same	Same	Same	Moderate	Moderate	Slightly difficult.	Fair or poor.	Range.
Moderate	Same	Same	Same	High	Moderate	Difficult	Fair or poor.	Range.

SOILS OF THE DESCHUTES AREA, OREGON:

Soil or land type	Map symbol	Soil Profile			Depth [1]
		Surface soil	Subsoil	Underlying material	
					(Feet)
Era sandy loam, 0 to 3 percent slopes.	Ea	Grayish-brown sandy loam grading to light brownish gray or brown; noncalcareous; when moist, very dark grayish brown and very friable; little pumice sand.	Brown to grayish-brown slightly hard sandy loam or light loam; noncalcareous in upper part; commonly lime-coated rock fragments in lower part.	Lime-coated basalt	2 to 3
Era sandy loam, 3 to 7 percent slopes.	Ec	Same	Same	Lime-coated basalt	2 to 3
Era sandy loam, 7 to 12 percent slopes.	Ee	Same	Same	Lime-coated basalt	2 to 3
Era sandy loam, 12 to 20 percent slopes.	Eg	Same	Same	Lime-coated basalt	2 to 3
Era sandy loam, eroded, 0 to 3 percent slopes.	Eb	Same	Same	Lime-coated basalt	1.8 to 3
Era sandy loam, eroded, 3 to 7 percent slopes.	Ed	Same	Same	Lime-coated basalt	1.8 to 3
Era sandy loam, eroded, 7 to 12 percent slopes.	Ef	Same	Same	Lime-coated basalt	1.8 to 3
Era sandy loam, eroded, 12 to 20 percent slopes.	Eh	Same	Same	Lime-coated basalt	1.8 to 3
Gem clay loam, eroded, 3 to 12 percent slopes.	Ga	Grayish-brown to dark grayish-brown or dark gray, noncalcareous clay loam; fine granular structure; when wet, very dark gray or very dark grayish brown and plastic.	Clay or heavy clay loam that is slightly lighter colored than surface soil; grades to brown with depth; very hard and dense; subangular blocky structure; lower part lighter colored than upper part and splotched with white lime.	Lime-coated basalt fragments over basalt bedrock.	2.5 to 4
Gem clay loam, eroded, 12 to 20 percent slopes.	Gb	Same	Same	Same	2 to 4
Gem clay loam, shallow, 7 to 12 percent slopes.	Gc	Same	Same	Same	1 to 1.4
Gem clay loam, shallow, eroded, 7 to 12 percent slopes.	Gd	Same	Same	Same	1 to 1.4
Gem loam, 3 to 7 percent slopes	Ge	Grayish-brown to dark grayish-brown or dark-gray, noncalcareous loam; fine granular structure; when wet, very dark gray or very dark grayish brown and plastic.	Heavy clay loam that is slightly lighter colored than surface soil; grades to brown with depth; very hard and dense; subangular blocky structure; lower part lighter colored than upper part and splotched with lime.	Same	2.5 to 4
Gem loam, 7 to 12 percent slopes	Go	Same	Same	Same	2.5 to 4
Gem loam, eroded, 7 to 12 percent slopes.	Gs	Same	Same	Same	2.2 to 4
Laidlaw sandy loam, 0 to 3 percent slopes.	La	Grayish-brown sandy loam grading to brown or light brownish gray; single grain; noncalcareous; when moist, very dark grayish brown and very friable; mostly pumice.	Pale-brown noncalcareous sandy loam; weak subangular blocky structure; gravelly loamy sand in lower part; mostly pumice.	Light-gray, splotched with yellowish brown, weakly to strongly cemented pumice flow material.	2 to 3
Laidlaw sandy loam, 3 to 7 percent slopes.	Lb	Same	Same	Same	2 to 3
Laidlaw sandy loam, 7 to 12 percent slopes.	Lc	Same	Same	Same	2 to 3
Laidlaw sandy loam, eroded, 7 to 12 percent slopes.	Ld	Same	Same	Same	2 to 3

See footnotes at end of table.

SUMMARY OF IMPORTANT CHARACTERISTICS—Continued

Water-holding capacity [2]	Drainage through the soil [3]			Erosion hazard under irrigation	Natural fertility [4]	Ease of irrigation [5]	Workability [6]	Principal use
	Surface soil	Subsoil	Underlying material					
Moderate to high.	Moderate to rapid.	Moderate to rapid.	Very slow; in places, slow or none.	Slight	Moderate	Very easy	Very good	Dry-farmed wheat; range.
Same	Same	Same	Same	Moderate	Moderate	Slightly difficult.	Very good	Dry-farmed wheat; range.
Same	Same	Same	Same	High	Moderate	Difficult	Good	Dry-farmed wheat; range.
Same	Same	Same	Same	Very high	Moderate	Very difficult.	Fair	Range; dry-farmed grain.
Same	Same	Same	Same	Slight	Moderate	Very easy	Very good	Dry-farmed wheat; range.
Same	Same	Same	Same	Moderate	Moderate	Slightly difficult.	Very good	Dry-farmed wheat; range.
Same	Same	Same	Same	High	Moderate	Difficult	Good	Dry-farmed wheat; range.
Same	Same	Same	Same	Very high	Moderate	Very difficult.	Fair	Range; dry-farmed wheat.
High	Moderate to slow.	Slow	Very slow	Moderate	High	Slightly difficult.	Fair	Dry-farmed grains; range.
High	Same	Slow	Very slow	High	High	Very difficult.	Poor to fair.	Dry-farmed grains; range.
Moderate to low.	Same	Slow	Very slow	Moderate to high.	High to moderate.	Difficult	Fair	Range.
Same	Same	Slow	Very slow	Same	Same	Difficult	Fair	Range.
High	Moderate	Slow	Very slow	Moderate	High	Easy	Good	Dry-farmed wheat.
High	Moderate	Slow	Very slow	Moderate	High	Slightly difficult.	Good	Range.
High	Moderate	Slow	Very slow	Moderate	High	Same	Good	Range.
Somewhat low to moderate.	Somewhat rapid.	Somewhat rapid.	Very slow to slow.	Slight	Low to moderate.	Very easy to easy.	Very good	Irrigated crops and pasture; range.
Same	Same	Same	Same	Moderate	Same	Slightly difficult.	Very good	Range; irrigated crops and pasture.
Same	Same	Same	Same	High	Same	Difficult	Good	Range; irrigated crops and pasture.
Same	Same	Same	Same	High	Same	Difficult	Good	Irrigated crops and pasture; range.

SOILS OF THE DESCHUTES AREA, OREGON

Soil or land type	Map symbol	Soil Profile			Depth [1]
		Surface soil	Subsoil	Underlying material	*(Feet)*
Laidlaw sandy loam, eroded, 12 to 20 percent slopes.	Le	Same	Same	Same	1.5 to 3
Lamonta loam, 0 to 3 percent slopes.	Lf	Grayish-brown noncalcareous slightly hard loam; fine granular structure; neutral reaction; when moist, very dark brown or very dark grayish brown.	Dark-brown, brown, or dark grayish-brown, noncalcareous clay; weak prismatic structure that breaks into very hard, dense subangular blocky aggregates with a colloidal coating; lighter colored and highly calcareous in lower part.	Partly consolidated sandstone agglomerate, or cobbly and stony fluvial deposits; in places, rhyolite, basalt, or other lava.	2 to 3
Lamonta loam, 3 to 7 percent slopes.	Lh	Same	Same	Same	2 to 3
Lamonta loam, 7 to 12 percent slopes.	Lm	Same	Same	Same	2 to 3
Lamonta loam, 12 to 20 percent slopes.	Lo	Same	Same	Same	1.5 to 3
Lamonta loam, eroded, 0 to 3 percent slopes.	Lg	Same	Same	Same	1.6 to 2.8
Lamonta loam, eroded, 3 to 7 percent slopes.	Lk	Same	Same	Same	1.6 to 2.8
Lamonta loam, eroded, 7 to 12 percent slopes.	Ln	Same	Same	Same	1.6 to 2.8
Lamonta loam, eroded, 12 to 20 percent slopes.	Lp	Same	Same	Same	1.4 to 2.8
Lamonta loam, shallow, 0 to 3 percent slopes.	Lr	Same	Same	Same	1 to 1.4
Lamonta loam, shallow, 3 to 7 percent slopes.	Ls	Same	Same	Same	1 to 1.4
Lamonta loam, shallow, eroded, 3 to 7 percent slopes.	Lt	Same	Same	Same	1 to 1.4
Lamonta loam, shallow, eroded, 7 to 12 percent slopes.	Lu	Same	Same	Same	1 to 1.4
Lamonta loam, stony, 0 to 3 percent slopes.	Lv	Grayish-brown, noncalcareous, slightly hard stony loam; fine granular structure; neutral reaction; when moist, very dark brown or very dark grayish brown.	Dark-brown, brown, or dark grayish-brown, noncalcareous stony clay; weak prismatic structure that breaks into very hard, dense angular blocky aggregates with a colloidal coating; lighter colored and highly calcareous in lower part.	Same	1.4 to 3
Lamonta loam, stony, 3 to 7 percent slopes.	Lw	Same	Same	Same	1.4 to 3
Lamonta loam, stony, 7 to 12 percent slopes.	Lx	Same	Same	Same	1.4 to 3
Lamonta sandy clay loam, 0 to 3 percent slopes.	Ly	Grayish-brown, noncalcareous, hard sandy clay loam; fine granular structure; neutral reaction; when moist, very dark brown or very dark grayish brown.	Dark-brown to brown or dark grayish-brown, noncalcareous clay; weak prismatic structure that breaks into very hard, dense angular blocky aggregates with a colloidal coating; lighter colored and highly calcareous in lower part.	Same	2 to 3
Lamonta sandy clay loam, 3 to 7 percent slopes.	Lea	Same	Same	Same	3 to 3
Lamonta sandy clay loam, 7 to 12 percent slopes.	Led	Same	Same	Same	1.7 to 3

See footnotes at end of table.

SUMMARY OF IMPORTANT CHARACTERISTICS—Continued

Water-holding capacity [2]	Drainage through the soil [3]			Erosion hazard under irrigation	Natural fertility [4]	Ease of irrigation [5]	Workability [6]	Principal use
	Surface soil	Subsoil	Underlying material					
Same	Same	Same	Same	High	Same	Very difficult.	Fair	Irrigated crops and pasture; range.
Moderate to somewhat high.	Moderate	Very slow or slow.	Slow	Slight	Somewhat high.	Very easy	Very good	Dry-farmed wheat; range.
Same	Moderate	Same	Slow	Moderate	Somewhat high.	Slightly difficult.	Very good	Dry-farmed wheat; range.
Same	Moderate	Same	Slow	High	Somewhat high.	Difficult	Good	Range; dry-farmed wheat.
Same	Moderate	Same	Slow	Very high	Somewhat high.	Very difficult.	Fair	Range.
Same	Moderate	Same	Slow	Slight	Somewhat high.	Very easy	Good	Dry-farmed wheat; range.
Same	Moderate	Same	Slow	Moderate	Somewhat high.	Slightly difficult.	Good	Dry-farmed wheat; range.
Same	Moderate	Same	Slow	High	Somewhat high.	Difficult	Fair	Range; dry-farmed wheat.
Same	Moderate	Same	Slow	Very high	Somewhat high.	Very difficult.	Fair	Range; dry-farmed wheat.
Somewhat low.	Moderate	Same	Slow	Slight	Moderate	Very easy	Very good	Range.
Same	Moderate	Same	Slow	Moderate	Moderate	Slightly difficult.	Very good	Range; dry-farmed wheat.
Same	Moderate	Same	Slow	Moderate	Moderate	Same	Good	Range; dry-farmed wheat.
Same	Moderate	Same	Slow	High	Moderate	Difficult	Fair	Range; dry-farmed wheat.
Moderate to somewhat high.	Moderate	Same	Slow	Slight	Somewhat high:	Easy	Very poor	Range.
Same	Moderate	Same	Slow	Moderate	Somewhat high.	Slightly difficult.	Very poor	Range.
Same	Moderate	Same	Slow	High	Somewhat high.	Difficult	Very poor	Range.
Same	Moderate to somewhat slow.	Same	Slow	Slight	Somewhat high.	Very easy	Good	Dry-farmed wheat; range.
Same	Same	Same	Slow	Slight to moderate.	Somewhat high.	Easy	Good	Range; dry-farmed wheat.
Same	Same	Same	Slow	High to moderate.	Somewhat high.	Slightly difficult.	Fair	Range; dry-farmed wheat.

SOILS OF THE DESCHUTES AREA, OREGON:

Soil or land type	Map symbol	Soil Profile			Depth [1]
		Surface soil	Subsoil	Underlying material	
					(Feet)
Lamonta sandy clay loam, eroded, 0 to 3 percent slopes.	Lz	Same	Same	Same	1.7 to 3
Lamonta sandy clay loam, eroded, 3 to 7 percent slopes.	Lec	Same	Same	Same	1.7 to 3
Lamonta sandy clay loam, eroded, 7 to 12 percent slopes.	Leh	Same	Same	Same	1.7 to 3
Lamonta sandy clay loam, eroded, 12 to 20 percent slopes.	Ler	Same	Same	Same	1.4 to 2.8
Lamonta sandy clay loam, shallow, 0 to 3 percent slopes.	Lev	Same	Same	Same	1 to 1.4
Lamonta sandy clay loam, shallow, 3 to 7 percent slopes.	Lsa	Same	Same	Same	1 to 1.4
Lamonta sandy clay loam, shallow, eroded, 3 to 7 percent slopes.	Lsb	Same	Same	Same	1 to 1.4
Lamonta sandy clay loam, shallow, eroded, 7 to 12 persent slopes.	Lsc	Same	Same	Same	1 to 1.4
Lamonta sandy clay loam, stony, 0 to 3 percent slopes.	Lsd	Grayish-brown, noncalcareous, hard stony sandy clay loam; fine granular structure; neutral reaction; when moist, very dark brown or very dark grayish brown.	Dark-brown, brown, or dark grayish-brown noncalcareous stony clay; weak prismatic structure that breaks into very hard, dense angular blocky aggregates with a colloidal coating; lighter colored and highly calcareous in lower part.	Same	1.7 to 3
Lamonta sandy clay loam, stony, 3 to 7 percent slopes.	Lse	Same	Same	Same	1.7 to 3
Lamonta sandy clay loam, stony, 7 to 12 percent slopes.	Lsl	Same	Same	Same	1.7 to 3
Lamonta sandy clay loam, stony, 12 to 20 percent slopes.	Lso	Same	Same	Same	1.7 to 3
Madras loam, 0 to 3 percent slopes.	Ma	Light brownish-gray to grayish-brown loam; noncalcareous; slightly hard; neutral reaction; very fine granular structure; when moist, very dark grayish brown.	Brown, hard clay loam grading to pale-brown or light yellowish-brown in lower part; subangular blocky structure; overlies white or very pale brown hardpan or caliche; noncalcareous except in lower part.	Partly consolidated tuffaceous or pumiceous sandstone or agglomerate.	1.7 to 2.5
Madras loam, 3 to 7 percent slopes.	Mc	Same	Same	Same	1.7 to 2.5
Madras loam, 7 to 12 percent slopes.	Me	Same	Same	Same	1.7 to 2.5
Madras loam, eroded, 0 to 3 percent slopes.	Mb	Same	Same	Same	1.5 to 2.5
Madras loam, eroded, 3 to 7 percent slopes.	Md	Same	Same	Same	1.5 to 2.5
Madras loam, eroded, 7 to 12 percent slopes.	Mf	Same	Same	Same	1.5 to 2.5

See footnotes at end of table.

SUMMARY OF IMPORTANT CHARACTERISTICS—Continued

Water-holding capacity [3]	Drainage through the soil [3]			Erosion hazard under irrigation	Natural fertility [4]	Ease of irrigation [5]	Workability [6]	Principal use
	Surface soil	Subsoil	Underlying material					
Same	Same	Same	Slow	Slight	Somewhat high.	Very easy	Good	Dry-farmed wheat; range.
Same	Same	Same	Slow	Moderate	Somewhat high.	Easy	Good	Range; dry-farmed wheat.
Same	Same	Same	Slow	High to moderate.	Somewhat high.	Slightly difficult.	Fair	Range; dry-farmed wheat.
Same	Same	Same	Slow	Very high	Somewhat high.	Difficult	Fair to poor.	Range; dry-farmed wheat.
Somewhat low.	Same	Same	Slow	Slight	Somewhat high.	Very easy	Good	Range.
Same	Same	Same	Slow	Slight to moderate.	Somewhat high.	Easy	Good	Range.
Same	Same	Same	Slow	Same	Somewhat high.	Easy	Good	Range.
Same	Same	Same	Slow	Moderate to high.	Somewhat high.	Slightly difficult.	Fair	Range.
Moderate to somewhat high.	Same	Same	Slow	Slight	Somewhat high.	Easy	Very poor	Range.
Same	Same	Same	Slow	Slight to moderate.	Somewhat high.	Slightly difficult.	Very poor	Range.
Same	Same	Same	Slow	High to moderate.	Somewhat high.	Difficult	Very poor	Range.
Same	Same	Same	Slow	Very high	Somewhat high.	Very difficult.	Very poor	Range.
Same	Moderate	Moderate; through hardpan, very slow ranging to none or slow.	Slow	Slight	Moderate	Very easy	Very good	Dry-farmed wheat.
Same	Moderate	Same	Slow	Moderate	Moderate	Slightly difficult to easy.	Very good	Dry-farmed wheat; range.
Same	Moderate	Same	Slow	High	Moderate	Difficult	Good	Range; dry-farmed wheat.
Same	Moderate	Same	Slow	Slight	Moderate	Very easy	Very good	Dry-farmed wheat.
Same	Moderate	Same	Slow	Moderate	Moderate	Slightly difficult.	Very good	Dry-farmed wheat; range.
Same	Moderate	Same	Slow	High	Moderate	Difficult	Good	Dry-farmed wheat; range.

SOILS OF THE DESCHUTES AREA, OREGON:

Soil or land type	Map symbol	Soil Profile			Depth [1]
		Surface soil	Subsoil	Underlying material	
					(Feet)
Madras loam, over sandstone, 0 to 3 percent slopes.	Mg	Same	Brown, hard, light clay loam or heavy loam grading to pale brown or light yellowish brown in lower part; subangular blocky structure; overlies weakly cemented hardpan or soft caliche; noncalcareous except in lower part.	Same	1.5 to 2.5
Madras loam, over sandstone, 3 to 7 percent slopes.	Mk	Same	Same	Same	1.5 to 2.5
Madras loam, over sandstone, eroded, 0 to 3 percent slopes.	Mh	Same	Same	Same	1.5 to 2.5
Madras loam, over sandstone, eroded, 3 to 7 percent slopes.	Ml	Same	Same	Same	1.5 to 2.5
Madras loam, stony, 0 to 3 percent slopes.	Mm	Light brownish-gray to grayish-brown stony loam; noncalcareous; slightly hard; very fine granular structure; neutral reaction; when moist, very dark grayish brown.	Brown, hard stony clay loam grading to pale brown or light yellowish brown in lower part; subangular blocky structure; overlies white or very pale-brown hardpan or caliche; noncalcareous except in lower part.	Same	1.5 to 2.5
Madras loam, stony, 3 to 7 percent slopes.	Mn	Same	Same	Same	1.5 to 2.5
Madras loam, stony, 7 to 12 percent slopes.	Mo	Same	Same	Same	1.5 to 2.5
Madras loamy sand, over sandstone, 3 to 7 percent slopes.	Mp	Light brownish-gray to grayish-brown soft loamy sand; single grain; neutral reaction.	Brown, noncalcareous, hard sandy clay loam or heavy loam; subangular blocky structure; overlies weakly to strongly cemented limey sandstone or agglomerate.	Same	1.4 to 3
Madras loamy sand, over sandstone, eroded, 3 to 7 percent slopes.	Mr	Same	Same	Same	1.3 to 3
Madras sandy loam, 0 to 3 percent slopes.	Ms	Light brownish-gray to grayish-brown, soft or slightly hard sandy loam; noncalcareous; single grain; when moist, very dark grayish brown and very friable; neutral reaction.	Brown hard sandy clay loam or clay loam grading to pale brown or light yellowish brown in lower part; subangular blocky structure; overlies white or very pale brown hardpan or caliche; noncalcareous except in lower part.	Same	1.7 to 2.5
Madras sandy loam, 3 to 7 percent slopes.	Mu	Same	Same	Same	1.7 to 2.5
Madras sandy loam, 7 to 12 percent slopes.	My	Same	Same	Same	1.3 to 2.5
Madras sandy loam, deep over sandstone, 0 to 3 percent slopes.	Mea	Same	Brown hard sandy clay loam or clay loam; subangular blocky structure; overlies weakly to strongly cemented sandstone or agglomerate; noncalcareous except in lower part and cemented layer.	Same	3 to 4

See footnotes at end of table.

SUMMARY OF IMPORTANT CHARACTERISTICS—Continued

Water-holding capacity [2]	Drainage through the soil [3]			Erosion hazard under irrigation	Natural fertility [4]	Ease of irrigation [5]	Workability [6]	Principal use
	Surface soil	Subsoil	Underlying material					
Same	Moderate	Moderate; lower part, slow.	Slow	Slight	Moderate	Very easy	Very good	Range; dry-farmed wheat.
Same	Moderate	Same	Slow	Moderate	Moderate	Slightly difficult.	Very good	Dry-farmed wheat; range.
Same	Moderate	Same	Slow	Slight	Moderate	Very easy	Very good	Dry-farmed wheat.
Same	Moderate	Same	Slow	Moderate	Moderate	Slightly difficult.	Very good	Dry-farmed wheat; range.
Same	Moderate	Moderate; through hardpan, very slow, ranging to none or slow.	Slow	Slight	Moderate	Easy	Very poor	Range.
Same	Moderate	Same	Slow	Moderate	Moderate	Slightly difficult.	Very poor	Range.
Same	Moderate	Same	Slow	High	Moderate	Difficult	Very poor	Range.
Low	Rapid	Moderate; through hardpan, very slow, or slow.	Slow	Moderate	Moderate to somewhat low.	Slightly difficult.	Very good	Range; dry-farmed wheat; irrigated crops and pasture.
Same	Rapid	Same	Slow	Moderate	Same	Same	Very good	Dry-farmed wheat.
Moderate	Moderate to somewhat rapid.	Moderate; through hardpan, very slow, ranging to none or slow.	Slow	Slight	Moderate	Very easy	Very good	Dry-farmed wheat.
Moderate	Same	Same	Slow	Moderate	Moderate	Slightly difficult.	Very good	Dry-farmed wheat.
Moderate	Same	Same	Slow	High	Moderate	Difficult	Good	Range; dry-farmed wheat.
Somewhat high.	Same	Moderate; through hardpan, very slow, or slow.	Slow	Negligible	Moderate	Very easy	Very good	Dry-farmed wheat; irrigated crops.

SOILS OF THE DESCHUTES AREA, OREGON:

Soil or land type	Map symbol	Soil Profile			Depth [1]
		Surface soil	Subsoil	Underlying material	(*Feet*)
Madras sandy loam, deep over sandstone, 3 to 7 percent slopes.	Meb	Same	Same	Same	3 to 4
Madras sandy loam, deep over sandstone, eroded, 3 to 7 percent slopes.	Mec	Same	Same	Same	3 to 4
Madras sandy loam, eroded, 0 to 3 percent slopes.	Mt	Same	Brown hard sandy clay loam or clay loam grading to pale brown or light yellowish brown in lower part; subangular blocky structure; overlies white or very pale brown hardpan or caliche; noncalcareous except in lower part.	Same	1.5 to 2.5
Madras sandy loam, eroded, 3 to 7 percent slopes.	Mv	Same	Same	Same	1.5 to 2.5
Madras sandy loam, eroded, 7 to 12 percent slopes.	Mz	Same	Same	Same	1.5 to 2.5
Madras sandy loam, over sandstone, 0 to 3 percent slopes.	Med	Light brownish-gray to grayish-brown, soft or slightly hard sandy loam; noncalcareous; single grain; when moist, very dark grayish brown and very friable; neutral reaction.	Brown to pale-brown hard sandy clay loam, light clay loam, or heavy loam; subangular blocky structure; overlies weakly to strongly cemented hardpan; noncalcareous except in lower part.	Same	1.4 to 3
Madras sandy loam, over sandstone, 3 to 7 percent slopes.	Meh	Same	Same	Same	1.4 to 3
Madras sandy loam, over sandstone, 7 to 12 percent slopes.	Meo	Same	Same	Same	1.4 to 3
Madras sandy loam, over sandstone, 12 to 20 percent slopes.	Mla	Same	Same	Same	1.4 to 3
Madras sandy loam, over sandstone, eroded, 0 to 3 percent slopes.	Mef	Same	Same	Same	1.4 to 3
Madras sandy loam, over sandstone, eroded, 3 to 7 percent slopes.	Mel	Same	Same	Same	1.4 to 3
Madras sandy loam, over sandstone, eroded, 7 to 12 percent slopes.	Mes	Same	Same	Same	1.4 to 3
Madras sandy loam, over sandstone, eroded, 12 to 20 percent slopes.	Mlc	Same	Same	Same	1.4 to 3
Madras sandy loam, shallow over sandstone, 0 to 3 percent slopes.	Mld	Same	Same	Same	1 to 1.4
Madras sandy loam, shallow over sandstone, 3 to 7 percent slopes.	Mle	Same	Same	Same	1 to 1.4
Madras sandy loam, shallow over sandstone, 12 to 20 percent slopes.	Moc	Same	Same	Same	1 to 1.4
Madras sandy loam, shallow over sandstone, eroded, 3 to 7 percent slopes.	Mlo	Same	Same	Same	1 to 1.4
Madras sandy loam, shallow over sandstone, eroded, 7 to 12 percent slopes.	Mls	Same	Same	Same	1 to 1.4

See footnotes at end of table.

SUMMARY OF IMPORTANT CHARACTERISTICS—Continued

Water-holding capacity [2]	Drainage through the soil [3]			Erosion hazard under irrigation	Natural fertility [4]	Ease of irrigation [5]	Workability [6]	Principal use
	Surface soil	Subsoil	Underlying material					
Same	Same	Same	Slow	Moderate	Moderate	Easy to slightly difficult.	Very good	Dry-farmed wheat; irrigated crops.
Same	Same	Same	Slow	Moderate	Moderate	Same	Very good	Dry-farmed wheat; range; irrigated crops.
Moderate	Same	Moderate; through hardpan, very slow, ranging to none or slow.	Slow	Slight	Moderate	Very easy	Very good	Dry-farmed wheat.
Moderate	Same	Same	Slow	Moderate	Moderate	Slightly difficult.	Very good	Dry-farmed wheat.
Moderate	Same	Same	Slow	High	Moderate	Difficult	Good	Dry-farmed wheat; range.
Moderate	Same	Moderate; through hardpan, very slow or slow.	Slow	Slight	Moderate	Very easy	Very good	Dry-farmed wheat; irrigated crops and pasture; range.
Moderate	Same	Same	Slow	Moderate	Moderate	Slightly difficult.	Very good	Same.
Moderate	Same	Same	Slow	High	Moderate	Difficult	Good	Range; dry-farmed wheat.
Moderate	Same	Same	Slow	Very high	Moderate	Very difficult.	Fair	Range; dry-farmed wheat.
Moderate	Same	Same	Slow	Slight	Moderate	Very easy	Very good	Dry-farmed wheat.
Moderate	Same	Same	Slow	Moderate	Moderate	Slightly difficult.	Very good	Dry-farmed wheat; range.
Moderate	Same	Same	Slow	High	Moderate	Difficult	Good	Dry-farmed wheat; range.
Moderate	Same	Same	Slow	Very high	Moderate	Very difficult.	Fair	Range.
Low	Same	Same	Slow	Slight	Moderate to low.	Easy to slightly difficult.	Very good	Range; irrigated crops and pasture; dry-farmed grains.
Low	Same	Same	Slow	Moderate	Same	Difficult	Very good	Dry-farmed grains; range.
Low	Same	Same	Slow	Very high	Same	Very difficult.	Fair	Range.
Low	Same	Same	Slow	Moderate	Same	Difficult	Very good	Range; dry-farmed grain.
Low	Same	Same	Slow	High	Same	Difficult to very difficult.	Good	Range.

SOILS OF THE DESCHUTES AREA, OREGON:

Soil or land type	Map symbol	Soil Profile			Depth [1]
		Surface soil	Subsoil	Underlying material	
					(Feet)
Madras sandy loam, stony, over sandstone, 0 to 3 percent slopes.	Mod	Light brownish-gray to grayish-brown, soft or slightly hard stony sandy loam; noncalcareous; single grain; when moist, very dark grayish brown and very friable; neutral reaction.	Brown to pale-brown hard sandy clay loam, or clay loam; stony; subangular blocky structure; overlies weakly to strongly cemented hardpan; noncalcareous except in lower part.	Partly consolidated tuffaceous or pumiceous sandstone or agglomerate; stony.	1.4 to 3
Madras sandy loam, stony, over sandstone, 3 to 7 percent slopes.	Moe	Same	Same	Same	1.4 to 3
Madras sandy loam, stony, over sandstone, 7 to 12 percent slopes.	Mol	Same	Same	Same	1.4 to 3
Madras sandy loam, stony, over sandstone, 12 to 20 percent slopes.	Mos	Same	Same	Same	1.4 to 3
Metolius sandy loam, 0 to 3 percent slopes.	Mta	Light brownish-gray to grayish-brown noncalcareous sandy loam; contains light yellowish-brown or very pale brown pumice sand; when moist, very dark grayish brown and very friable.	Pale-brown to light brownish-gray slightly hard sandy loam; contains pumice similar to that in surface soil; generally calcareous below 23 inches.	Stratified sandy loam, loamy sand, or gravelly sandy material; calcareous.	3 to 5+
Metolius sandy loam, 3 to 7 percent slopes.	Mtd	Same	Same	Same	3 to 5+
Metolius sandy loam, 7 to 12 percent slopes.	Mts	Same	Same	Same	3 to 5+
Metolius sandy loam, eroded, 0 to 3 percent slopes.	Mtc	Same	Same	Same	3 to 5+
Metolius sandy loam, eroded, 3 to 7 percent slopes.	Mte	Same	Same	Same	3 to 5+
Metolius sandy loam, terrace position, 0 to 3 percent slopes.	Mtl	Same	Same	Same	3 to 5+
Metolius sandy loam, terrace position, 3 to 7 percent slopes.	Mto	Same	Same	Same	3 to 5+
Odin clay loam, 0 to 3 percent slopes.	Oa	Light brownish-gray or gray noncalcareous clay loam containing pumice sand; when wet, very dark grayish brown, sticky, and plastic; neutral.	Light brownish-gray or gray heavy clay loam containing pumice sand; massive or weak subangular blocky structure; when wet, dark grayish brown, sticky, and plastic; generally noncalcareous.	Partly consolidated pumice or tuffaceous sandstone or basalt.	3 to 4
Odin clay loam, 3 to 7 percent slopes.	Ob	Grayish-brown, noncalcareous clay loam containing pumice; when wet, very dark grayish brown, sticky, and plastic; neutral.	Grayish-brown clay loam; in places calcareous and moderately to strongly alkaline in lower subsoil.	Stratified sandy or gravelly alluvial material.	5+

See footnotes at end of table.

SUMMARY OF IMPORTANT CHARACTERISTICS—Continued

Water-holding capacity [2]	Drainage through the soil [3]			Erosion hazard under irrigation	Natural fertility [4]	Ease of irrigation [5]	Workability [6]	Principal use
	Surface soil	Subsoil	Underlying material					
Moderate	Moderate	Same	Slow	Slight	Moderate	Easy	Very poor	Range.
Moderate	Moderate	Same	Slow	Moderate	Moderate	Slightly difficult.	Very poor	Range.
Moderate	Moderate	Same	Slow	High	Moderate	Difficult	Very poor	Range.
Moderate	Moderate	Same	Slow	Very high	Moderate	Very difficult.	Very poor	Range.
Moderate to somewhat high.	Somewhat rapid.	Somewhat rapid.	Variable, generally rapid.	Slight	Moderate	Very easy	Very good	Dry-farmed wheat; range.
Same	Same	Same	Same	Moderate	Moderate	Easy to slightly difficult.	Very good	Dry-farmed wheat; range.
Same	Same	Same	Same	High	Moderate	Difficult	Good	Dry-farmed wheat; range.
Same	Same	Same	Same	Slight	Moderate	Very easy	Very good	Dry-farmed wheat; range.
Same	Same	Same	Same	Moderate	Moderate	Easy to slightly difficult.	Very good	Dry-farmed wheat; range.
Same	Same	Same	Same	Slight	Moderate	Very easy	Very good	Dry-farmed wheat; range; irrigated orchards.
Same	Same	Same	Same	Moderate	Moderate	Easy to slightly difficult.	Very good	Same.
Very high	Slow except in areas that have a high water table.	Slow except in areas that have a high water table.	Slow except in areas that have a high water table.	Negligible	Moderate	Very easy	Good to fair.	Irrigated grains, alsike clover, and pasture; dry-farmed wheat.
Very high	Same	Same	Same	Moderate	Moderate	Easy	Good	Range.

SOILS OF THE DESCHUTES AREA, OREGON:

Soil or land type	Map symbol	Soil Profile			Depth [1]
		Surface soil	Subsoil	Underlying material	
					(Feet)
Odin sandy loam, 0 to 3 percent slopes.	Oc	Light brownish-gray to light-gray, noncalcareous, friable sandy loam; when moist, very dark grayish brown; neutral; contains much pumice sand.	Light brownish-gray firm to friable sandy clay loam or clay loam; subangular blocky structure; when wet, dark grayish brown; generally few very dark gray iron and manganese stains; generally noncalcareous.	Partly consolidated pumiceous or tuffaceous sandstone; stratified.	3 to 4
Redmond clay loam, 0 to 3 percent slopes.	Ra	Light brownish-gray to grayish-brown, noncalcareous light clay loam; when moist, very dark grayish brown; contains pumice sand.	Pale-brown to light yellowish-brown or light brownish-gray, hard clay loam; subangular blocky structure; when moist, dark grayish-brown; contains pumice sand; noncalcareous except in lower part.	Basalt bedrock or partly consolidated sandstone or agglomerate.	2.5 to 3.5
Redmond loam, 0 to 3 percent slopes.	Rb	Light brownish-gray to grayish-brown noncalcareous loam; when moist, very dark grayish brown; contains much pumice sand.	Pale-brown to light yellowish-brown or light brownish-gray, hard, light clay loam; subangular blocky structure; much pumice sand; noncalcareous except in lower part.	Same	2.5 to 3.5
Redmond sandy loam, 0 to 3 percent slopes.	Rc	Light brownish-gray to grayish-brown noncalcareous sandy loam; when moist, very dark grayish brown and very friable; contains much pumice.	Pale-brown or light yellowish-brown heavy loam or light clay loam; subangular blocky structure; contains much pumice; noncalcareous except in lower part.	Same	2.5 to 3.5
Redmond sandy loam, 3 to 7 percent slopes.	Rd	Same	Same	Same	2.5 to 3.5
Redmond sandy loam, deep, 0 to 3 percent slopes.	Re	Same	Same	Same	3 to 5
Riverwash	Rk	Loose sand, gravel, and stones.	Loose sand, gravel, and stones.	Variable	Variable
Rough broken land, Era and Deschutes soil materials, 12 to 50 percent slopes.	Ro	Variable	Variable	Variable	Variable
Rough stony land, Agency and Deschutes soil materials, 12 to 60 percent slopes.	Rs	Variable; stony	Variable	Variable	Variable
Scabland, 0 to 3 percent slopes	Sa	Variable	Variable	Variable	Variable
Scabland, 3 to 12 percent slopes	Sb	Variable	Variable	Variable	Variable
Volcanic ash, 0 to 3 percent slopes	Vo	Light-gray or white glassy or pumiceous loose loamy sand, sand, or sandy loam.	Same as surface soil but slightly firmer.	Pale-brown fine sandy loam containing weakly cemented aggregates.	4+

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[1] Depth is the distance from the surface to bedrock, cemented layer, or other material that seriously impedes the penetration of roots, air, and moisture. It also refers to depth to loose gravel and other coarse-textured material. It does not refer to the depth to fine-textured or clayey layers. 5+ means 5 feet or more.

[2] The water-holding capacity refers to the quantity of water that a soil at field moisture capacity holds available to plants within the normal root zone. Field moisture content is approximately the moisture content of a well-drained soil 2 or 3 days after thorough wetting.

[3] Drainage through the soil refers to the rate of the downward movement of water through the soil. Unless otherwise stated, the water table is assumed to be so far below the surface that it does not interfere with drainage through the soil.

SUMMARY OF IMPORTANT CHARACTERISTICS—Continued

Water-holding capacity [2]	Drainage through the soil [3]			Erosion hazard under irrigation	Natural fertility [4]	Ease of irrigation [5]	Workability [6]	Principal use
	Surface soil	Subsoil	Underlying material					
Very high	Somewhat rapid except in areas that have a high water table.	Same	Same	Negligible	Moderate	Very easy	Good to fair.	Irrigated crops and pasture.
High or very high.	Moderate	Moderate to somewhat slow.	Very slow; in places, slow or none.	Negligible or slight.	Moderate	Very easy	Good	Irrigated crops and pasture.
High	Moderate	Moderate	Same	Negligible	Moderate	Very easy	Very good	Irrigated crops and pasture.
Moderate to somewhat high.	Somewhat rapid.	Moderate	Same	Negligible or slight.	Moderate	Very easy	Very good	Irrigated crops and pasture.
Same	Same	Moderate	Same	Moderate	Moderate	Easy to slightly difficult.	Very good	Irrigated crops and pasture; dry-farmed wheat.
Same	Same	Moderate	Same	Negligible	Moderate	Very easy	Very good	Same.
Very low	Very rapid	Very rapid	Variable	Variable	Very low	Variable	Very poor	None.
Variable	Variable	Variable	Variable	High or very high.	Variable	Very difficult.	Fair to very poor.	Range.
Variable	Variable	Variable	Variable	Same	Variable	Very difficult.	Very poor or impossible.	Range.
Variable	Variable	Variable	Variable	Slight	Variable	Easy or slightly difficult.	Impossible	Range; irrigated pasture.
Variable	Variable	Variable	Variable	Variable	Variable	Very difficult.	Impossible	Range.
Low	Rapid	Rapid	Moderate	Slight	Very low	Easy	Very good	Range.

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[4] Natural fertility is the quality that enables a soil to provide the proper elements in the proper amounts and in the proper balance to support plant growth, when other factors, such as light, temperature, and the physical condition of the soil, are favorable.

[5] Ease of irrigation refers to the relative ease or difficulty of leveling and grading the soil and distributing irrigation water.

[6] Workability refers to the relative ease or difficulty of tilling the soil and harvesting the crops.

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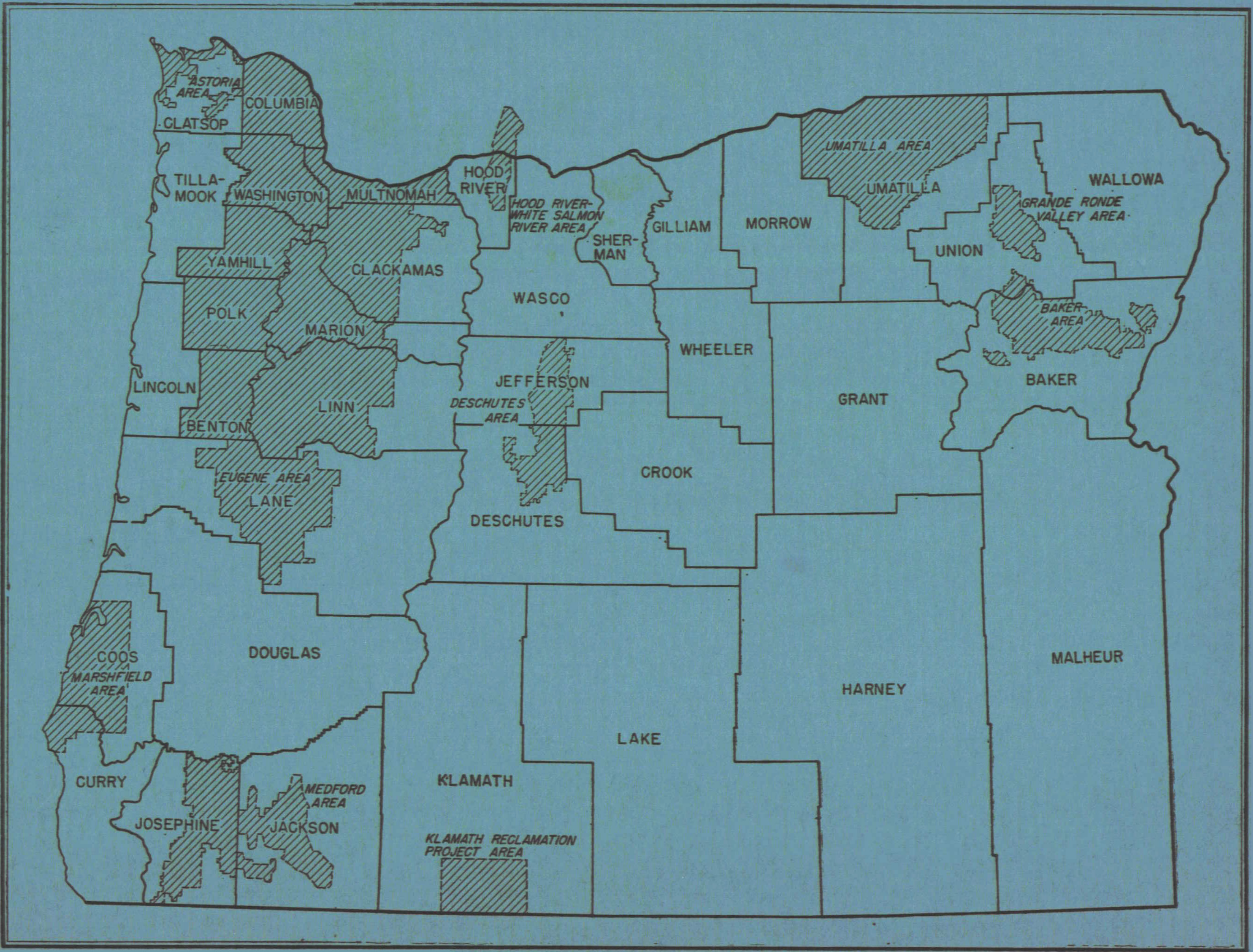

Areas surveyed in Oregon shown by shading.

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Series 1955, No. 12

Issued February 1966

SOIL SURVEY

Prineville Area Oregon

This is the last report of 1955 series

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
Oregon Agricultural Experiment Station

HOW TO USE THIS SOIL SURVEY REPORT

THIS SOIL SURVEY of the Prineville Area, Oreg., contains information that can be applied in managing farms, ranches, and rangeland; in selecting sites for roads, ponds, buildings, and other structures; and in appraising the value of tracts of land for agriculture, industry, or recreation.

cDn.

Locating Soils

All the soils of the Prineville Area are shown on the detailed map at the back of this report. This map consists of many sheets that are made from aerial photographs. Each sheet is numbered to correspond with numbers shown on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbol. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information in the report. This guide lists all the soils of the Area in alphabetic order by map symbol. It shows the page where each kind of soil is described, and also the page for the capability unit in which the soil has been placed.

Individual colored maps showing the relative suitability or limitations of soils for many specific purposes can be developed by using the soil map and information in the text. Interpretations not included in the text can be developed by grouping the soils according to their suitability or limitations for a particular use. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers, ranchers, and those who work with them can learn about use and management of the soils in the soil descriptions and in the discussions of the interpretative groupings.

Engineers and builders will find under "Use of Soils in Engineering" tables that give engineering descriptions of the soils in the Area and that name soil features that affect engineering practices and structures.

Scientists and others can read about how the soils were formed and how they are classified in the section "Formation, Classification, and Morphology of Soils."

Students, teachers, and others will find information about soils and their management in various parts of the text.

Newcomers in the Prineville Area may be especially interested in the section "General Soil Map" where broad patterns of soils are described. They may also be interested in the section "Facts About Crook County," which gives additional information.

* * * * *

Fieldwork for this survey was completed in 1955. Unless otherwise indicated, all statements in the report refer to conditions in the Area at the time the survey was in progress. This soil survey of the Prineville Area is a cooperative survey made by the Soil Conservation Service and the Oregon Agricultural Experiment Station.

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Contents

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SOIL SURVEY OF THE PRINEVILLE AREA, OREGON

BY R. W. MAYKO AND GEORGE K. SMITH, SOIL CONSERVATION SERVICE

FIELDWORK BY GEORGE K. SMITH AND HAROLD BIGGERSTAFF, SOIL CONSERVATION SERVICE,
AND ELWOOD DULL, OREGON AGRICULTURAL EXPERIMENT STATION

UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH THE OREGON AGRICULTURAL EXPERIMENT STATION

THE PRINEVILLE AREA lies between the Cascade and the Ochoco Mountains in the central part of Oregon. It occupies about 275 square miles of Crook County (fig. 1). Prineville, the county seat, is in the western part of the county and is near the center of the Area.

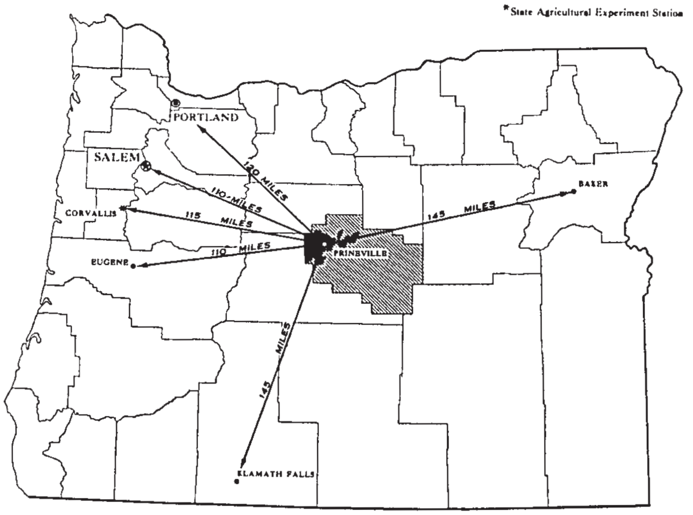

Figure 1.—**Location of the Prineville Area (shown in black) in Crook County, Oregon.**

The Prineville Area is drained by the Crooked River and its tributaries, Ochoco, McKay, Lytle, Johnson, and Mill Creeks. The Ochoco Reservoir, formed by damming Ochoco Creek just below its confluence with Mill Creek, controls flooding and is the only place available in the Area for storing irrigation water in quantity. In addition, streamflow is used for irrigation by diverting water at several dams built on other creeks. Alluvial flood plains occur mainly along Ochoco Creek and the Crooked River and range from ½ to 1 mile in width.

Climate in the Area is semiarid, though winter is cold and moist. In summer the days are warm but the nights are cool, and frost has been recorded in every month. In general, the annual precipitation increases with elevation northward and eastward from Prineville. It is about 9 inches at Prineville and about 18 inches at the Ochoco Ranger Station.

How Soils Are Mapped and Classified

Soil scientists made this survey to learn what kinds of soils are in the Prineville Area, where they are located, and how they can be used.

They went into the Area knowing they likely would find many soils they had already seen, and perhaps some they had not. As they traveled over the Area, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; kinds of rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by roots of plants.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. To use this report efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Deschutes and Ochoco, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that go with their behavior in the natural, untouched landscape. Soils of one series can differ somewhat in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in texture of their surface layer. According to such differences in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Deschutes sandy loam and Deschutes loamy sand are two soil types in the Deschutes series. The difference in texture of their surface layers is apparent from their names.

Some soil types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into phases. The name of a soil phase indicates a feature that affects management. For example, Deschutes sandy loam, 0 to 2 percent slopes, is one of several phases of Deschutes sandy loam, a soil type that ranges from nearly level to moderately steep.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that greatly help in drawing boundaries accurately. The soil map in the back of this report was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning management of farms and fields, a mapping unit is nearly equivalent to a soil type or a phase of a soil type. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil type or soil phase.

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils are so intricately mixed, and so small in size, that it is not practical to show them separately on the map. Therefore, they show this mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soil in it, for example, Searles-Slayton complex, 2 to 20 percent slopes.

In a few places it is desirable to show two or more soil types or soil phases, which are similar but do not regularly occur together, as one mapping unit. Such groups are called undifferentiated soil groups. They are named in terms of their constituent soils and connected by "and." Ayres and Ochoco sandy loams, 0 to 2 percent slopes, is an example of an undifferentiated soil group.

In addition, on most soil maps, areas are shown that are so rocky, so shallow, or so frequently worked by wind and water that they scarcely can be called soils. These areas are shown on a soil map like other mapping units, but they are given descriptive names, such as Rock land or Riverwash, and are called land types rather than soils.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soils in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soils. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in a way that it is readily useful to different groups of readers, among them farmers, ranchers, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in the soil survey reports. On the basis of the yield tables and other data, the soil scientists set up trial groups, and test them by further study and by consultation with farmers, agronomists, engineers, and others. Then, the scientists adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

After studying the soils in a locality and the way they are arranged, a soil scientist can make a general map that shows the main patterns of soils, called soil associations. Such a map is the colored general soil map in the back of this report. Each association, as a rule, contains a few major soils and several minor soils, in a pattern that is characteristic though not strictly uniform.

The soils within any one association are likely to differ in many properties; for example, slope, depth, stoniness, or natural drainage. Thus, the general soil map does not show the kind of soil in any particular place, but patterns of soils, in each of which are several different kinds of soils.

Each soil association is named for the major soil series in it, but as already noted, soils of other series may also be present. The major soils of one soil association may also be present in another association, but in a different pattern.

The general map is useful to people who want a general idea of the soils, who want to compare different parts of the survey area, or who want to learn the possible location of good-sized areas suitable for a certain kind of farming or other land use.

The Prineville Area lies in the Columbia Plateau province in north-central Oregon. Soil associations 1, 2, 3, and 5 are on flood plains, terraces, low benches, and alluvial fans. They contain soils that formed mainly in sediments deposited by streams. Soil associations 4 and 9 occur on the basaltic plateau and consist of soils with hardpan, soils formed from pumiceous material, and shallow, stony soils. Soil associations 6, 7, and 8 are on uplands and on buttes and hills, but the soils in associations 6 and 8 formed in material derived from rhyolite rock and tuff, whereas those in association 7 formed mainly in basaltic material.

1. Polly-Veazie-Ontko association: Soils on flood plains and alluvial fans in narrow valleys

This association is in the narrow valleys (fig. 2) of Mill Creek, upper McKay Creek, and Ochoco Creek above Ochoco Reservoir. It occupies about 3 percent of the survey area.

The Polly soils, which make up about 35 percent of the association, are on alluvial fans above the flood plain and below the steep uplands. Slopes of the Polly soils range from 0 to 20 percent. The well-drained Veazie soils are on the nearly level flood plain and cover about 35 percent of the association. The poorly drained and very poorly drained Ontko soils also are on the nearly level flood plain and occupy about 20 percent of the association. Veazie and Ontko soils are frequently flooded for short periods in spring. In the remaining 10 percent of the association are the well-drained Steiger sandy loam and other alluvial soils.

The Polly soils have a dark-gray or grayish-brown loam to sandy loam surface layer, which is gravelly or

Figure 2.—**Irrigated soils in a narrow valley, Polly-Veazie-Ontko soil association.**

stony in places, and a grayish-brown to reddish-brown clay loam subsoil. The surface layer of the Veazie soils is dark-gray loam to gravelly sandy loam that is underlain by layers similar to it except for their grayish-brown color. Very gravelly or sandy underlying material occurs at a depth of 18 to 40 inches. Ontko soils have a neutral clay loam or clay surface layer that is black when moist. The subsurface layer is similar but is mottled. A substratum of stratified silty clay loam to loamy coarse sand occurs below a depth of about 2 feet. Although roots easily penetrate the substratum, their growth is hindered by a water table that fluctuates between the depths of 18 and 36 inches during much of the year. Steiger sandy loam is an ashy, pumiceous soil with a grayish-brown surface layer and brown to pale-brown lower layers. This soil is easily penetrated by roots to a depth of 5 feet or more.

Most of this association is irrigated and is used mainly for hay crops and as summer pasture for beef cattle. Some of the acreage of Polly soils is dryfarmed to small grain. Chiefly because of wetness and the frost hazard, the association generally is not well suited to potatoes. If the soils are well irrigated and are adequately drained, they produce good forage in summer. Except on the poorly drained Ontko soils, fair yields of alfalfa are produced under irrigation.

2. Powder-Boyce-Metolius association: Soils on flood plains and low benches in broad valleys

This association occupies the nearly level flood plain and low benches along the Crooked River and its major tributaries (fig. 3). It amounts to about 11 percent of the survey area. In many places, particularly south and west of Prineville, the association is adjoined by steep canyon walls.

About 35 percent of the association is well-drained Powder soils, 15 percent is poorly drained or very poorly drained Boyce soils, and 20 percent is well-drained or somewhat excessively drained, pumiceous Metolius soils. About 15 percent consists of the sandy Crooked soils, which are sodic, or alkali, and the remaining 15 percent is mainly Riverwash and Stearns and Forester soils.

Powder soils are loamy, moderately deep to very deep over sand and gravel, and generally calcareous below a depth of 1 to 2 feet. The Boyce soils lie in depressional areas below the Powder soils and are mottled from surface to substratum. Metolius soils have a surface layer of light brownish-gray sandy loam, loamy sand, or loam and a subsoil of sandy loam or loamy sand. The Metolius soils are underlain by gravel and sand, generally at a depth of 6 feet or more. The Crooked soils, like the Metolius soils, were derived mainly from pumice. Crooked soils have a light brownish-gray loamy sand to loam surface layer

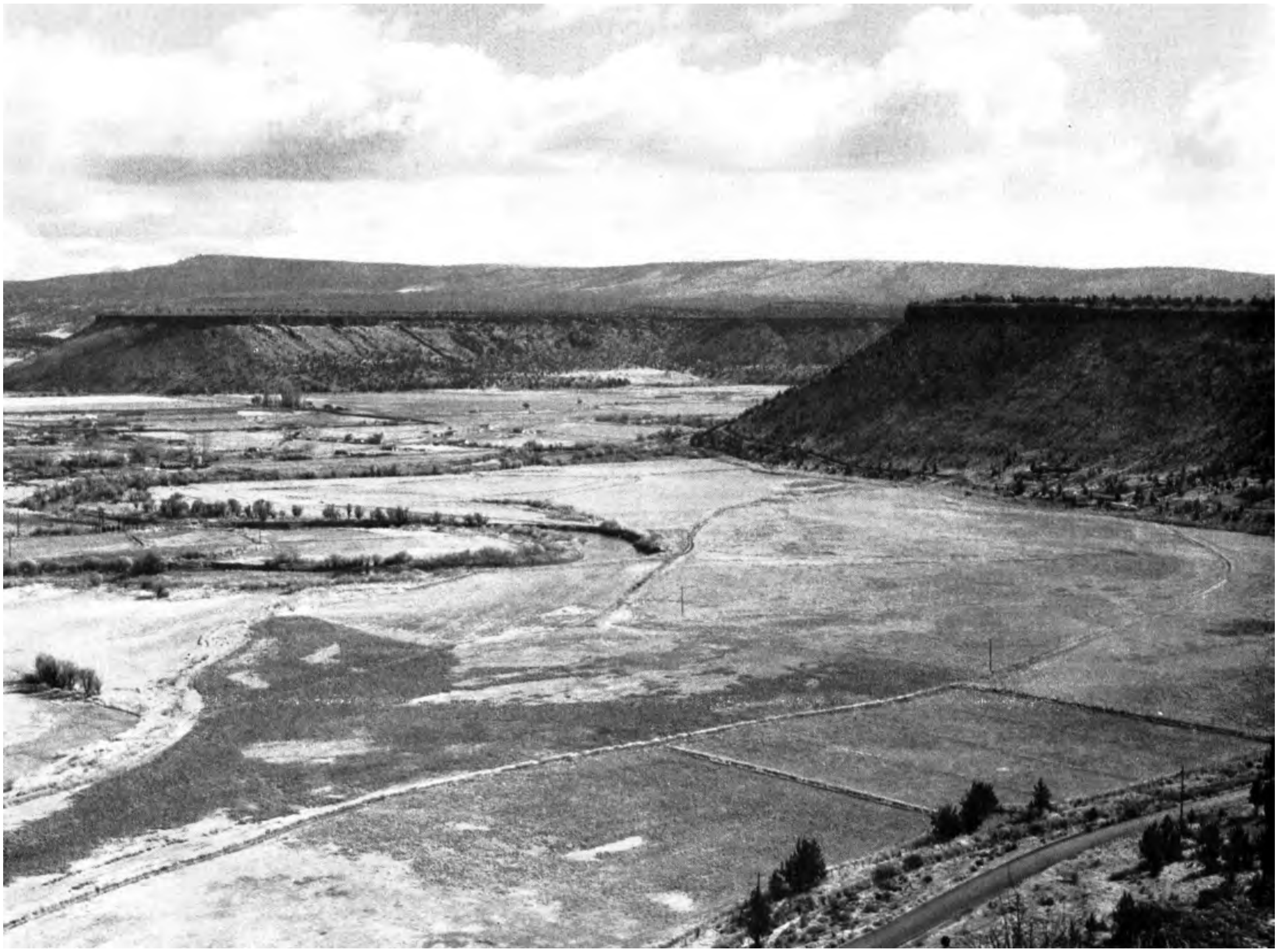

Figure 3.—**Landscape in the Powder-Boyce-Metolius soil association showing valley of the Crooked River in the foreground and valley of Ochoco Creek at extreme left. Patchy stand of alfalfa is on Crooked soils, which are sodic, or alkali.**

that is very strongly alkaline and slightly calcareous. In many places the subsoil is higher in alkali content than the surface layer. A strongly cemented hardpan occurs at a depth of 12 to 36 inches.

Minor components of this association are Riverwash, Stearns soils, and Forester soils. Riverwash consists mostly of barren, unstable sand and gravel along the Crooked River and smaller streams. The Stearns soils have a silt loam surface layer and generally a silty clay loam subsoil. The content of exchangeable sodium in Stearns soils is medium to high in the surface layer and is even higher in the subsoil. Forester soils are like Crooked soils but do not have a hardpan.

Most of this association is used for irrigated crops, principally hay and pasture for beef cattle. The Metolius, Powder, and other well-drained soils also are used for potatoes and other row crops. The other soils generally are not well suited to potatoes, mainly because of imperfect drainage or alkali. Boyce soils are commonly too wet for alfalfa, and the Stearns soils are too strongly affected by alkali for good yields of that crop. The Crooked and Forester soils are suited to alfalfa, though productivity is lowered by alkali. On Crooked and Forester soils the yields of alfalfa can be increased by using practices that reduce the accumulation of alkali. The other soils in the association produce good yields of alfalfa. Improved pasture can be grown on nearly all the soils by selecting suitable grasses and legumes, reducing the alkali content where necessary and feasible, providing adequate drainage, and irrigating the soils properly.

Most of the city of Prineville is on this association, mainly on Stearns and Crooked soils. Although some of the residential acreages around Prineville are farmed part time, most of the agriculture is on large ranches.

3. Ochoco-Prineville-Courtrock association: Soils on terraces and broad alluvial fans

This association occupies about 11 percent of the Prineville Area and occurs in four separate areas north of lower Ochoco Creek and the Crooked River. About two-thirds of the association is on slopes of 6 percent or less. The general relief is that of a nearly level or gently sloping terrace that is interrupted in places by shallow drainageways and terrace escarpments. Slopes of these escarpments range from 6 to 40 percent but generally are 12 to 20 percent. Above the terrace lie broad alluvial fans.

About 40 percent of the association is well-drained Ochoco soils, 35 percent is well-drained Prineville soils, and 10 percent is Courtrock soils. The rest is chiefly Ayres and Slayton soils.

The Ochoco and the Prineville soils occur on terraces and terrace escarpments. Ochoco soils have a surface layer of light brownish-gray to grayish-brown loamy sand, sandy loam, or loam that is gravelly in places. Their subsoil commonly is gravelly sandy clay loam and is underlain, at a depth of 20 to 36 inches, by a weakly to strongly cemented hardpan. Except for their fine sandy loam subsoil, the Prineville soils are similar to the Ochoco soils. The Courtrock soils lie on alluvial fans, are light brownish gray, and do not have a hardpan.

The Ayres soils in this association occur on terrace escarpments. These soils are like the Ochoco soils but are 12 to 20 inches deep to hardpan. Slayton soils occupy low foothills and are underlain by bedrock at a depth of 8 to 20 inches.

Most farms on this association are irrigated and diversified. Raising beef cattle and growing potatoes are the main enterprises, though some dairy herds and flocks of sheep are kept. The soils generally are among the most productive of the survey area. Except for those on terrace escarpments and in wet drainageways, these soils are well suited to all crops commonly grown, and few problems arise in their management. Properly managing irrigation water is the chief concern.

Some of the association is dryfarmed to small grain that is used mostly as hay for cattle. A small acreage is in pasture and range. The northern part of the city of Prineville is on this association.

4. Deschutes-Redmond-Bakeoven association: Soils from pumiceous material and shallow, stony soils on the basaltic plateau

This association occurs on the basaltic plateau west and south of the Crooked River and westward to the Deschutes County line. It is the largest association in the survey area and makes up about 30 percent of the total acreage. The Dry River, flowing from south to north, passes through the major part of the association and empties into the Crooked River. Several smaller areas are east of the community of Powell Butte. In most places the relief is gentle, but west of the Dry River the gentle slopes are broken by small mounds or knolls of basalt rock and by long, narrow ridges of bare basalt (*4*, *8*).[1] These mounds and ridges generally rise 5 to 25 feet above the general terrain. East of the Dry River they occur in only a few places.

Most extensive are the Deschutes soils, which make up about 45 percent of the association. Redmond soils cover about 25 percent, and Bakeoven soils 20 percent. In the remaining 10 percent are Rock land, Rock outcrop, and Swartz silt loam.

Deschutes soils are light brownish-gray sandy loams and loamy sands that are 18 to 54 inches deep to a substratum that is basalt bedrock in most places. The grayish-brown, pumiceous Redmond soils have a loam to clay loam subsoil and are 16 to 36 inches deep over bedrock. The grayish-brown, very stony Bakeoven soils were derived mainly from basalt. Rock land consists of rock outcrops and areas of shallow, stony Deschutes or Bakeoven soils. Swartz silt loam occupies basins with no outlets and is imperfectly drained; it has a clay or silty clay subsoil.

Three-fourths or more of this association is range, and most of the rest is irrigated. All crops grown in the survey area are suited to the Deschutes and Redmond soils that are nonstony and have slopes of not more than 6 percent. Most of the diversified irrigated farms in the association are on these soils in the vicinity of Powell Butte. Along the Dry River, in the southwestern part of the association, is a small irrigated area that consists of Deschutes and Redmond soils and the alluvial Metolius soils. Water wasted in the irrigation of other crops is used to produce pasture on the stony Deschutes soils and the very stony Bakeoven soils.

The main farming enterprises are raising beef cattle, producing potatoes, and dairying. A few flocks of sheep are kept. Nearly all the area west of the Dry River is in range, most of which is overgrazed and in poor condition. The plant cover in this area is dominated by juniper, sagebrush, and rabbitbrush. Some of the acreage could be irrigated if water were available, but areas of Rock land and Rock outcrop would make the distribution of water difficult.

5. Ayres-Ochoco-Deschutes association: Soils with hardpan on alluvial fans and soils from pumiceous materials

This association makes up about 11 percent of the survey area and lies at the foot of the Powell Buttes (fig. 4), which rise to an elevation of more than 5,000 feet. In this association are alluvial fans consisting of soil materials that came from the Powell Buttes and were derived from rhyolite. The Ayres and Ochoco soils formed in these materials. The alluvial fans are on slopes of 0 to 12 percent, are most strongly sloping just below the buttes, and are nearly level at the lower end, or toe. In most places they are 1 to 2 miles long. No perennial streams pass through this association.

About 70 percent of the association consists of Ayres and Ochoco soils. About 25 percent is occupied by the Deschutes soils, which are mostly moderately deep or deep over hardpan. The remaining acreage is chiefly Searles and Bakeoven soils.

The Ayres soils have a surface layer of light brownish-gray sandy loam that is gravelly or stony in many places. Their subsoil is gravelly or stony clay loam and is underlain by an indurated gravelly hardpan at a depth of 12 to 20 inches. The Deschutes soils are light brownish-gray, pumiceous sandy loams and loamy sands that are underlain, in some places, by soil material that is like an Ayres soil or, in other places, by gravel that washed from the buttes in intermittent streams. The Ochoco soils are similar to the Ayres soils but are 20 to 36 inches deep to hardpan. Searles soils are light brownish-gray to grayish-brown, stony soils that developed in material derived from rhyolite or tuff bedrock. The very stony Bakeoven soils were derived mainly from basalt bedrock.

Much of this association lies above existing canals and is not irrigated. Most areas below the canals are irrigated and are used mainly for potatoes and for hay and pasture

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[1] Italic numbers in parentheses refer to Literature Cited, p. 87.

Figure 4.—Irrigated pasture on Ayres, Ochoco, and Deschutes soils that occupy an alluvial fan at the base of the Powell Buttes in the Ayres-Ochoco-Deschutes soil association. Buttes in the background are in the Searles-Elmore soil association.

for beef cattle. Yields generally are good, though in places where the soils are sloping and of limited depth, leveling and irrigating are fairly difficult.

Some areas above irrigation canals were formerly dryfarmed to wheat and then abandoned. Of these abandoned areas, some were seeded to crested wheatgrass that formed good stands, and others were invaded by cheatgrass, rabbitbrush, and some sagebrush. A few dryland areas are now cultivated, principally to rye that is used mainly as hay for beef cattle.

6. Searles-Elmore association: Soils from rhyolite rock on buttes and hills

This association occurs on the Powell Buttes and in the area of Barnes Butte northeast of Prineville. It covers about 4 percent of the survey area. Slopes range from 2 to 40 percent but are 20 to 40 percent in most places. The soils were derived mainly from rhyolite.

About 60 percent of the association consists of the stony Searles soils, and 20 percent consists of Elmore very stony loam, 6 to 40 percent slopes. Rock land and Rock outcrop make up about 15 percent, and the Ayres and Ochoco soils account for most of the rest.

In most places the Searles soils have a surface layer of light brownish-gray to grayish-brown stony loam, stony clay loam, or stony sandy loam. Generally, their subsoil is stony or gravelly clay loam and overlies rhyolite bedrock at a depth of 16 to 40 inches. Most of the acreage in Searles soils is on south-facing slopes. The Elmore soil typically has a grayish-brown surface layer and a clay loam subsoil over rhyolite bedrock at a depth of 2 to 5 feet. This soil commonly occupies north-facing slopes. Rock land and Rock outcrop occur principally with the Searles soils. The Ayres soils have a light brownish-gray surface layer and a gravelly or stony clay loam subsoil over an indurated gravelly hardpan at a depth of 12 to 20 inches. The Ochoco soils are like the Ayres soils but are 20 to 36 inches deep to hardpan.

Almost all of this association is used for pasture and range. A few small areas of Ayres and Ochoco soils are dryfarmed, mainly to small grain that is grown for hay and fed to cattle. On the Elmore soil the plant cover consists of bunchgrasses—chiefly Idaho fescue, bluebunch wheatgrass, and Sandberg bluegrass—and sagebrush, rabbitbrush, and juniper. Except for Idaho fescue, these plants also make up most of the cover on the Searles soils. The Elmore soil, however, generally has denser stands of bunchgrasses and provides better grazing in summer than the Searles soils, which are most suitable for grazing in spring and fall.

7. Gem-Lookout-Agency association: Soils mainly from basaltic material, on uplands

This association occurs in eight individual areas of the Prineville Area and makes up about 19 percent of the total acreage. It is characterized by steep or very steep topography, but small parts have milder slopes. The pattern of drainage is well defined.

About 20 percent of the association is Gem soils, 25 percent is Lookout soils, and 20 percent is Agency soils.

Rock land and Bakeoven soils account for about 20 percent. The rest consists mainly of Salisbury, Deschutes, and Redmond soils, and there is a small acreage of Day clay.

The stony Gem soils have a grayish-brown loam or clay loam surface layer and a clay loam subsoil. These soils are underlain by basalt bedrock at a depth of 1 to 3 feet. The Lookout soils were derived from basalt; they have a light brownish-gray loam surface layer, a clay loam subsoil and, at a depth of 18 to 36 inches, a strongly cemented hardpan. Most of the acreage in Lookout soils is very stony. The Agency soils were derived from sedimentary and basaltic rocks and are very stony. They have a light brownish-gray sandy loam surface layer and a clay loam subsoil, and they are underlain by bedrock at a depth of 18 to 40 inches.

Also in this association are areas of Rock land and of Bakeoven, Salisbury, Deschutes, Redmond, and Day soils. Rock land consists of rock outcrops that occur with Gem, Lookout, and Agency soils and with Bakeoven soils. The Salisbury soils lie on alluvial fans, commonly below the Gem soils, and were derived from basaltic alluvium. In these soils the surface layer is grayish-brown loam, the subsoil is clay, and a hardpan is 16 to 24 inches below the surface. Most of the acreage in Salisbury soils is very stony. The Deschutes soils are pumiceous, light brownish-gray sandy loams and loamy sands. Redmond soils are grayish brown and are pumiceous in the surface layer, but they have a loam or clay loam subsoil. The Day soil is reddish-brown clay.

A few small areas of this association are dryfarmed, mainly to rye, but nearly all the acreage is in range or dryland pasture that is grazed along with nearby irrigated fields. The vegetation consists chiefly of bunchgrasses, sagebrush, rabbitbrush, juniper, and bitterbrush. Stands of bunchgrasses are denser on north-facing slopes than on south-facing ones.

8. Searles-Slayton association: Soils from tuff and rhyolite rock on uplands

This association occurs on upland areas that are just above areas of Courtrock, Ochoco, and Prineville soils on alluvial fans and terraces. Most of it is hilly and is underlain by tuff bedrock. The association occupies about 4 percent of the Prineville Area.

The Searles soils make up about 35 percent of this association, and the Slayton soils cover about 30 percent. Gem soils make up about 10 percent. Rock land occurs with all of these soils and accounts for about 10 percent of the total acreage. Most of the rest is Lamonta and Polly soils.

The stony Searles soils have a surface layer of light brownish-gray to grayish-brown sandy loam to clay loam and a subsoil of clay loam. Tuff bedrock generally occurs at a depth of 16 to 40 inches. The Slayton soils have a light brownish-gray sandy loam surface layer and a sandy loam subsoil. Under these layers is tuff bedrock at a depth of 8 to 20 inches. In the stony Gem soils the surface layer is grayish-brown loam or clay loam, and the subsoil is clay loam. Basalt bedrock is 1 to 3 feet below the surface. The Lamonta soils are on alluvial fans and formed in alluvium derived from rhyolite, tuff, and basalt. They have a light brownish-gray loam surface layer, a clay subsoil, and an indurated gravelly hardpan at a depth of 18 to 30 inches. The Polly soils have a dark-gray or grayish-brown surface layer and a clay loam subsoil.

Most of this association is used for pasture and range. A few small areas were dryfarmed and then were abandoned. Later, some of these areas were seeded to crested wheatgrass, and others were invaded by cheatgrass and rabbitbrush. Much of this association is overgrazed, and juniper is increasing in the stand.

9. Ayres-Ochoco-Bakeoven-Deschutes association: Soils with hardpan and soils from pumiceous material on the basaltic plateau

This association occupies about 7 percent of the survey area. Most of it is on slopes of 0 to 6 percent and is underlain by basalt. The drainage pattern is not prominent.

About 60 percent of the association consists of Ayres and Ochoco soils. About 15 percent is Bakeoven soils, and 15 percent is Deschutes soils. The remaining acreage consists chiefly of Redmond and Agency soils.

The Ayres soils have a light brownish-gray surface layer, a gravelly or cobbly clay loam subsoil and, at a depth of 12 to 20 inches, an indurated hardpan. In the Ochoco soils a hardpan occurs at a depth of 20 to 36 inches, but in other respects these soils are similar to the Ayres soils. Bakeoven soils are very stony and are only 6 to 12 inches deep to basalt bedrock. Deschutes soils are pumiceous and have a surface layer of light brownish-gray sandy loam or loamy sand. The Redmond soils are grayish brown and are pumiceous, but their subsoil is loam or clay loam. The Agency soils are light brownish gray and very stony. They have a sandy loam surface layer and a clay loam subsoil over bedrock at a depth of 18 to 40 inches.

Nearly all of this association is used for range, and most of it has been heavily grazed. About one-third of the association is suitable for irrigation and, if water were available, could be irrigated. Under good management, range and pasture can safely be used in spring or in fall, or both, depending on the amount of important forage grasses that is grazed.

The Prineville Airport is on this association.

Use and Management of Soils

This section discusses principles of soil management, capability groups of soils, estimated yields of principal crops, and the use of soils in engineering.

Principles of Soil Management

Some of the principles and practices important in the use and management of soils in the Prineville Area are described in the following pages.

Crop rotations

A good crop rotation is essential in maintaining yields, improving fertility, and conserving soil and water. Higher yields can be obtained if potatoes are alternated with wheat or barley than if any of these crops is grown continuously. Growing potatoes or other row crops year after year tends to lower the content of plant nutrients and organic matter, causes gradual deterioration in soil structure, increases the risk of erosion, promotes disease and insect pests, and slows the rate of water intake. These effects can best be offset by using grasses and legumes in rotation with row crops and small grain.

Grasses and legumes are close-growing crops that have beneficial effects of the soil (*10*). Their abundant and extensive root system supplies organic matter, improves structure, decreases erosion, and raises the content of nitrogen and other nutrients. As a result, the soil produces higher yields of row crops and small grain if they are grown in rotation.

Crop rotations are not rigid in this Area, but generally a row crop is grown for 1 or 2 years, then a small grain for 1 year, and finally a legume for 4 to 6 years. The most common row crop is potatoes, and the principal small grains are wheat and barley, though some oats are grown. A small grain is frequently used as a companion, or nurse, crop for a new seeding of alfalfa or clover. By far the most important legume is alfalfa. If seeded pasture is included in the rotation, using alfalfa or clover mixed with alta fescue, smooth brome, or orchardgrass lessens the chance of bloat, provides forage of better balance and finer fiber, and results in a more extensive root system for improving soil structure. Such a rotation maintains productivity, and it also provides the flexibility needed to meet changing economic conditions in an area where potatoes are the most important row crop.

Organic matter

Maintaining or increasing the organic-matter content is probably the most important problem of soil management throughout the Area. All the soils have a low content of organic matter. It is less than 1.5 percent in many virgin soils and commonly ranges from 2.0 to 3.0 percent in the most favorable soils.

Organic matter is chiefly responsible for the larger and more stable forms of soil aggregation, and it improves permeability, aeration, and structure. It contains an appreciable amount of nitrogen—an element needed in large quantity by plants—as well as phosphorus, sulfur, and other essential plant nutrients. By serving as a source of energy for the micro-organisms that live in the soil, organic matter aids these organisms in making many of the essential nutrients available to plants.

Organic matter can be added to the soil by plowing under crop residues or green-manure crops, by applying barnyard manure, or by growing grasses and legumes in the crop rotation. Turning under crop residues is a desirable practice used by most farmers, though alone it does not provide enough material to maintain the organic-matter content at a satisfactory level. All plant residues should be returned to the soil except those harboring insect pests and those from greasewood, a shrub that accumulates salts in its tissues and is best removed from the farming area rather than plowed under or burned.

Not much barnyard manure is available on farms where potatoes or small grain is the principal crop and few or no livestock are kept. On these farms a suitable way to supply organic matter and plant nutrients to the soil is by turning under green-manure crops or by using grasses and legumes in the rotation. If alfalfa, clover, and other legumes are properly inoculated, they fix nitrogen from the air and may add several hundred pounds of nitrogen per acre when plowed under.

Grasses have an abundance of fine, fibrous roots that generally are well distributed throughout the upper part of the soil. As the roots slowly decay, they add organic matter to the soil and reduce the likelihood of erosion.

Tillage

Proper tillage is essential in the management of crops and soils. The main purposes of tillage are to prepare a good seedbed, to destroy weeds that compete with crops for water and nutrients, to improve the physical condition of the soil, and to control soil erosion. By providing a cloddy surface and retaining crop residues as a surface mulch, tillage on the contour or across the slope helps to control soil losses.

The soils in the Prineville Area are sandy and contain little organic matter. In the western part of the Area, where the soils generally have a low degree of aggregation, tillage loosens the surface layer, at least temporarily. If the content of organic matter were higher in these soils, the soil-improving effects of tillage would be greater and longer lasting.

Some farmers, especially potato growers, use subsurface chiseling to loosen the lower layers in the soil.

Leveling

In preparing soils for irrigation, leveling is needed almost everywhere in the survey area. If soils are properly leveled, water moves quickly and evenly over a field and wets the rooting zone to a uniform depth. After the first job of leveling, some floating is needed at least once a year so that high spots are eliminated, low spots are filled, and crops are irrigated uniformly without wasting water at the lower end of the field. Ordinarily, several years of floating are required before a field is properly leveled and the distribution of water is fast and efficient.

Salts and alkali

Of the soils on bottom land and low terraces, about one-fourth the acreage is sodic, or affected by alkali. Sodic soils have a high percentage of exchangeable sodium that is held by the soil particles. Exchangeable sodium affects soils by tending to (1) make them strongly alkaline, with high pH values, (2) replace the calcium, potassium, and magnesium that are exchangeable and are important as plant nutrients, (3) reduce the amount of water available to plants, and (4) disperse or puddle the soil so that water enters and moves through it at a reduced rate. Plants may be severely injured or even killed by sodic soils.

Also injurious to plants are excessive amounts of salts. Soils that contain soluble salts are called saline soils. In the Prineville Area, they are less common than alkali-affected soils and are a much less serious problem.

Plants differ in their tolerance of salts and exchangeable sodium. Some kinds of plants are much more tolerant than others, and some salts appear to be more harmful than others. Sprouting seeds and young seedlings are more easily injured than well-established plants. Alfalfa and other deep-rooted crops may be harmed by salts or alkali in the lower subsoil that do not affect shallow-rooted crops. At the soil surface, however, the same amount of salts or alkali might be injurious to all crops.

The effects of a given amount of salts and exchangeable sodium on sandy soils are more pronounced than on clayey soils, but their effects in clayey soils are more serious. Although a high content of moisture may decrease salinity, this is not enough to restore sodic soils to productivity. The undesirable effects of excess sodium generally are not evident, however, as long as considerable amounts of soluble salts are present.

On slightly sodic soils there is little injury to cultivated crops. On moderately sodic soils, all crops except the most tolerant ones are injured and their yields are reduced. Strongly sodic soils are not suitable for commercial crops, and they are either covered by saltgrass, greasewood, and other tolerant plants or are entirely bare of vegetation.

In this Area most saline soils also are sodic. Because the water used for irrigation contains only a small amount of soluble salts, reclamation can be directed mainly toward reducing the content of exchangeable sodium. In most places the salts are leached out if the excess sodium is removed.

In restoring sodic soils to productivity, two needs must be met. The first need is for adequate underdrainage and an improvement in soil structure so that water can move freely through the soil. The second is for applications of a chemical amendment containing exchangeable calcium to replace the sodium, for most soils in the Area do not have an adequate content of calcium. After the sodium is replaced, it can then be leached away.

Gypsum is an amendment commonly used as a source of calcium. Lime also contains calcium, but it is slowly soluble and its corrective action is slow. Sulfur aids in reclaiming soils that contain lime. If desired, lime and sulfur can be used together as a replacement for gypsum.

In the sodic soils of this Area, natural underdrainage is not adequate for much movement of water through the soil. If artificial drainage is provided, the nature of the soil determines the amount of water that can move though it.

The Stearns soils have a slowly permeable subsoil and a hardpan that prevent much reduction in the alkali content, even under the most favorable conditions. The Crooked soils, however, are more permeable above the hardpan and can be improved enough for shallow-rooted crops to be grown. Because the Forester soils are rapidly or very rapidly permeable throughout, they can be readily reclaimed if drainage is improved and seepage is eliminated. Reclaiming the Forester soils requires adequate drainage that keeps the water table at least 4 feet, but preferably 6 feet, below the surface.

Little use has been made of draining and leaching as means of improving sodic soils in the Prineville Area, but two drainage ditches have been constructed. These ditches are effective in lowering the water table in nearby soils, and both have helped in the reclamation of adjacent sodic fields.

Although most sodic soils in this Area can be reclaimed, the cost of reclamation may be too high at the present time. Sodic spots scattered in a productive field can be partly or completely reclaimed, and thereby improved for increased production of farm crops, by (1) providing for the prompt removal of surface and subsurface water, (2) plowing under moderate or large amounts of barnyard manure, and (3) using gypsum or sulfur and irrigating frequently until a crop is established.

Drainage

Artificial drainage is needed in most irrigated areas. Waterlogging is common in soils where internal drainage is too slow for excess irrigation water to drain away. Seepage causes wet spots and, in many places, a perched water table. A drainage system is especially needed in areas that are irrigated by gravity flow. In the Prineville Area, improved drainage is of primary concern on the terraces and bottom land in and around the city of Prineville.

Nearly all the irrigated acreage east of the Crooked River is gently sloping and occurs on high terraces and alluvial fans. Because many of the soils are underlain by a hardpan or a slowly permeable substratum, water tends to build up in the subsurface layers. At one time the draining of soils in these areas was mistakenly considered a matter of concern only to the individual farmer, who disposed of waste water from his farm by constructing small ditches and drains that carried the water to his neighbor's farm. Removing water in this way tends to aggravate the drainage problem, for excess water flowing downhill is likely to drown out the lower areas and to cause an accumulation of salts and sodium in the soils.

It is expected that additional water will be made available and more land will be brought under irrigation around the city of Prineville. If this expansion occurs, drainage is likely to worsen on the low terraces and the bottom land, unless it is corrected by installing a central system of drains or by forming a drainage district.

Many swales on the high terraces north of Prineville are much too wet for irrigation because of seepage or the lateral movement of water. Some of the swales have been dammed and are used to store water for irrigating nearby fields through sprinklers. An adequate system of drains is needed in this area.

In the Powell Butte community, water draining from the pumicy upland plateau is discharged into Huston Lake. Because the lake is permanent, it provides hunting, fishing, and other forms of recreation. In the adjacent soils, however, it also raises the ground water, which reduces yields of alfalfa and, in places, brings salts to the surface.

Fertilizer

The soils of this Area generally contain phosphorus and potassium in amounts adequate for crops. None of the soils contain much sulfur, an element needed for high yields. Also needed, but in smaller amounts, are calcium, iron, and magnesium. The supply of these elements generally is adequate in most soils, and many of the soils have an abundance of calcium and magnesium.

Soils throughout the Area generally are too low in nitrogen for adequate growth of plants; added nitrogen increases yields of nonlegumes. Potatoes respond to additions of phosphorus, and sulfur and phosphorus generally increase production of alfalfa and other legumes.

Among the minor elements needed for plant growth are copper, zinc, molybdenum, boron, chlorine, and manganese. None of the soils in the Prineville Area is naturally deficient in these elements, though shortages may occur in shallow, coarser textured soils that are heavily cropped.

Generally, potatoes respond most if fertilized with nitrogen, phosphorus, potassium, and sulfur. On soils where potatoes in the rotation are followed by small grain, a smaller amount of nitrogen is applied, but little or no phosphorus. Only phosphorus and sulfur are used on alfalfa, and nitrogen and phosphorus are used on pasture. On some strongly calcareous soils, alfalfa yields may be increased by adding phosphorus in split applications.

Except for potatoes, crops generally do not respond to a complete fertilizer, but one is likely to be needed on shallow, coarse-textured soils after only a short period of intensive cropping. Field trials indicate that sulfur is needed throughout the Area and that applications of sulfur increase crop yields significantly. Both gypsum and sulfur are used in reclaiming alkali-affected soils.

Irrigation

Most crops grown in the Prineville Area are irrigated. Water is applied by two general methods, surface irrigation and sprinkler irrigation (*11*).

SURFACE IRRIGATION

Crops in this Area are most commonly irrigated by surface methods. These are flood irrigation, furrow irrigation, and corrugation irrigation. In a field that is well prepared for flood irrigation, the water flows in a continuous sheet and is evenly distributed over the entire field. Most fields, however, are not prepared for efficient flooding and, if they are irrigated by this method, water is applied more heavily in some parts than in others. For this reason, there are several systems of flood irrigation in which the water is distributed on the field between borders, in basins, between contour borders, from contour ditches, by wild flooding, or from border ditches.

Border irrigation.—In border irrigation, water flows in a uniform sheet down a narrow strip between low ridges, or borders. The water enters the soil as it advances. Irrigating efficiently by this method requires strips that are level between the borders and have a uniform grade. Border irrigation is commonly used in the Area for irrigating alfalfa, clover, pasture, and other close-growing crops. A large volume of water is needed, but the labor requirement is low, water is efficiently used, and irrigation is uniform.

Basin irrigation.—In this method, a diked area is quickly filled with water to a desired depth. The water is then absorbed into the soil. Basin irrigation is most suitable for irrigating level soils and for reclaiming the Crooked, Forester, and other sandy soils affected by alkali.

Contour borders.—In this method, the borders are parallel and are laid out across the slope; between them are strips that resemble basins. Each strip is higher than the one just below it and is lower than the next strip above it. Applying water between contour borders is a suitable method of irrigating many sloping soils, but it cannot be successfully used in areas where the soils are pumicy.

Contour ditches.—In this method, the applied water flows down the slope between ditches laid out along the contour. The method is suitable for irrigating sloping soils east of the Crooked River. In the western part of the Area, where the soils are pumicy, the ditches do not hold well, because the pumice tends to float away.

Wild flooding.—This method consists of diverting a stream of water from its course and allowing it to spread over a field. Water is not applied uniformly, for low spots receive too much water and high spots too little. Consequently, crops in low areas may be drowned, and the salt content in high areas is increased.

Border ditches.—In this method, water is carried in ditches that run down the field in the direction of the slope. The ditches can be several hundred feet apart. Between them are strips that are irrigated by diverting water from the ditches. Unless drop boxes, headgates, and other control structures are installed, the ditches erode and more labor is required to spread the water over the field.

Furrow irrigation.—This is the most common method of applying water to row crops in the Area and is used for irrigating potatoes. The water is applied in furrows that are between the plant rows. On soils where the furrows run downslope, severe erosion is likely unless the size of the irrigating stream is well controlled.

Contour furrows.—This method is a slight modification of furrow irrigation. The furrows are laid out across the slope on a selected grade that is less than the general grade of the field. Reducing the grade of the furrows reduces the rate of flow and thereby lessens the risk of erosion.

Corrugation irrigation.—This method is suitable for irrigating close-growing crops on soils that are sloping to rolling and generally are too steep for either border or furrow irrigation. The water is taken from a head ditch and is applied downslope in small furrows. This is a good method of irrigating small grain in the Prineville Area.

SPRINKLER IRRIGATION

In this method, water is brought to a field in pipe under pressure and is sprinkled on the soil through nozzles. If a system of sprinklers is well designed and properly installed, water can be safely applied to soils that are too steep for other methods. The water is uniformly distributed and efficiently used. The cost of labor is reduced, the amount of water required is small, and the need for ditching and leveling is eliminated. Among the limitations on sprinkler irrigation are the high initial cost, the uneven distribution of water in windy periods, the large loss of water by evaporation, and the need for a supply of clean water.

Erosion

Erosion losses are caused principally by wind in the survey area, particularly on the coarser textured soils. Because most cultivated soils are nearly level, water erosion generally is a minor problem, though gullying occurs in some irrigation systems and in some waterways that carry flash runoff from sudden and heavy storms. Cultivated fields in fallow or on slopes of as much as 6 to 15 percent are subject to washing.

On the upland plateau the Deschutes and the Ayres soils, which developed from light-weight pumice, are subject to moderate wind erosion early in spring. During this period a cover of plants or crop residues is needed on these soils.

Many of the sandy soils in the Area were unsuccessfully dryfarmed years ago. After cultivation had been abandoned, the soils were moderately or severely eroded by wind and, in a few places, were marked by sandy blowouts. The erosion occurred mainly in the western part of the Area, where the coarser textured soils have a naturally low content of organic matter. On soils under irrigation, the hazard of wind erosion is much less severe.

Practices that help to control erosion on all cultivated soils are stubble mulching, cover cropping, and plowing under crop residues (*7*). Wind erosion can be greatly reduced on irrigated soils by wetting the soils just before and just after cultivation. Planting windbreaks and stripcropping at right angles to the prevailing wind are other measures for controlling wind erosion. Leveling, carefully using irrigation water, constructing grassed waterways, and installing drop boxes, headgates, and other irrigation structures are effective in the control of water erosion.

Capability Groups of Soils

The capability classification is a grouping that shows, in a general way, how suitable soils are for most kinds of farming. It is a practical grouping based on limitations of the soils, the risks of damage when they are used, and the way they respond to treatment.

In this system all the kinds of soil are grouped at three levels, the capability class, subclass, and unit. The eight capability classes in the broadest grouping are designated by Roman numerals I through III. In class I are the soils that have few limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater natural limitations. In class VIII are soils and landforms so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products.

The subclasses indicate major kinds of limitations within the classes. Within most of the classes there can be up to four subclasses. The subclass is indicated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* means that water in or on the soil will interfere with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony, and *c*, used in only some parts of the country, indicates that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few or no limitations. Class V can contain, at the most, only subclasses *w*, *s*, and *c*, because the soils in it are subject to little or no erosion but have other limitations that restrict their use largely to pasture, range, woodland, or wildlife.

Within the subclasses are the capability units, which are groups of soils enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally identified by numbers assigned locally, for example, IIe-1 or IIIe-2.

Soils are classified in capability classes, subclasses and units in accordance with the degree and kind of their permanent limitations; but without consideration of major and generally expensive reshaping that would change the slope, depth, or other characteristics of the soil; and without consideration of possible but unlikely major reclamation projects.

The eight classes in the capability system, and the subclasses and units in the Prineville Area, are described in the list that follows.

- Class I. Soils that have few limitations that restrict their use. No soils in the Prineville Area are in this class.
- Class II. Soils that have some limitations that reduce the choice of plants or require moderate conservation practices.
  - Subclass IIe. Soils subject to moderate erosion if they are not protected.
    - Capability unit IIe–1.—Moderately deep, well-drained, gently sloping soils that have a moderately coarse textured subsoil.
    - Capability unit IIe–2.—Deep, well-drained, gently sloping soils that have a moderately coarse textured or medium-textured subsoil.
    - Capability unit IIe–3.—Moderately deep, well-drained, gently sloping soils that have a medium-textured or moderately fine textured subsoil.
    - Capability unit IIe–4.—Shallow to deep, well-drained, nearly level or gently sloping soils that have a clayey subsoil.
    - Capability unit IIe–5.—Shallow, well-drained, gently sloping soils that have a hardpan.
    - Capability unit IIe–6.—Nearly level, moderately well drained or well drained soils of the flood plains that are occasionally flooded and subject to channeling and washing in spring.
  - Subclass IIs. Soils that have moderate limitations of moisture capacity or tilth.
    - Capability unit IIs–1.—Nearly level, well-drained, moderately deep soils that have a moderately coarse textured subsoil.
    - Capability unit IIs–2.—Nearly level, well-drained, deep soils that have a hardpan or a gravelly substratum.
    - Capability unit IIs–3.—Nearly level, well-drained soils that have a medium-textured or moderately fine textured subsoil or substratum.
    - Capability unit IIs–4.—Nearly level, shallow, well-drained soils that have a hardpan.
    - Capability unit IIs–5.—Nearly level, deep, moderately coarse textured or medium-textured soils.
  - Subclass IIc. Soils that have moderate limitations because of climate.
    - Capability unit IIc–1.—Deep, well-drained, nearly level soils on flood plains.
- Class III. Soils that have severe limitations that reduce the choice of plants, or require special conservation practices, or both.
  - Subclass IIIe. Soils subject to severe erosion if they are cultivated and not protected.
    - Capability unit IIIe–1.—Moderately deep, well-drained, sloping soils that have a moderately coarse textured subsoil.
    - Capability unit IIIe–2.—Deep, well-drained, sloping soils that have a moderately coarse textured or medium-textured subsoil.
    - Capability unit IIIe–3.—Shallow to deep, well-drained, sloping soils that have a medium-textured or moderately fine textured subsoil.
    - Capability unit IIIe–4.—Shallow or moderately deep, well-drained, sloping soils that have a hardpan.
  - Subclass IIIw. Soils that have severe limitations because of excess water.

Capability unit IIIw-1.—Well-drained to poorly drained soils that are on flood plains or in low areas on terraces and have moderate or moderately slow permeability.

Capability unit IIIw-2.—Imperfectly drained, pumiceous, mainly coarse textured or moderately coarse textured soils that contain alkali.

Subclass IIIs. Soils that have severe limitations of moisture capacity or tilth.

Capability unit IIIs-1.—Nearly level or gently sloping, well-drained to excessively drained soils that have very sandy upper layers.

Capability unit IIIs-2.—Nearly level or gently sloping, moderately coarse textured and medium-textured soils that are well drained or somewhat excessively drained.

Class IV. Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both.

Subclass IVe. Soils subject to very severe erosion if they are cultivated and not protected.

Capability unit IVe-1.—Sloping or moderately steep, well-drained, shallow to deep soils that have moderately slow to rapid permeability.

Subclass IVw. Soils that have very severe limitations for cultivation because of excess water.

Capability unit IVw-1.—Imperfectly drained soils that are in basins and have a clayey subsoil.

Capability unit IVw-2.—Poorly drained, clayey soils on flood plains.

Capability unit IVw-3.—Imperfectly drained, medium-textured soils that are affected by alkali and have a hardpan at a depth of 12 to 30 inches.

Subclass IVs. Soils that have very severe limitations because of coarse texture.

Capability unit IVs-1.—Moderately deep to very deep, sloping to moderately steep loamy sands that have very rapid permeability.

Capability unit IVs-2.—Nearly level or gently sloping, well-drained or somewhat excessively drained, shallow to deep, stony soils.

Class V. Soils not likely to erode that have other limitations, impractical to remove without major reclamation, that limit their use largely to pasture or range, woodland, or wildlife food and cover.

Subclass Vw. Soils too wet for cultivation; drainage or protection not feasible.

Capability unit Vw-1.—Frequently flooded, very poorly drained soils on bottom land.

Class VI. Soils that have severe limitations that make them generally unsuitable for cultivation and that limit their use largely to pasture or range, woodland, or wildlife food and cover.

Subclass VIe. Soils severely limited, chiefly by risk of erosion if protective cover is not maintained.

Capability unit VIe-1.—Nearly level to steep, stony soils.

Capability unit VIe-2.—Sloping to steep, stony soils that have a loamy surface layer and a clayey subsoil.

Class VII. Soils that have very severe limitations that make them unsuitable for cultivation without major reclamation and that restrict their use largely to range, woodland, or wildlife.

Subclass VIIs. Soils very severely limited by moisture capacity, stones, or other soil features.

Capability unit VIIs-1.—Nearly level to steep, shallow or moderately deep, very stony soils.

Capability unit VIIs-2.—Nearly level to moderately steep, very stony, generally shallow soils.

Capability unit VIIs-3.—Steep, stony, severely eroded soils and very steep, very stony soils.

Capability unit VIIs-4.—Nearly level to steep, shallow to deep, very stony soils.

Class VIII. Soils and landforms that, without major reclamation, have limitations that preclude their use for commercial production of plants and restrict their use to recreation, wildlife, water supply, mining, or esthetic purposes.

Subclass VIIIs. Rock or soil material that has little potential for production of vegetation.

Capability unit VIIIs-1.—Land types and soils that, in most places, are too stony or too rocky for agricultural use.

Management by capability units

In the following subsection, each of the capability units in the Prineville Area is described and the soils in it are listed. Suggestions are given on how to use and manage the soils in each unit.

CAPABILITY UNIT IIe-1

This unit consists of well-drained, moderately coarse textured soils that are 18 to 42 inches deep. Slopes range from 2 to 6 percent. These soils have rapid or moderately rapid permeability, low to moderate moisture-holding capacity, and low fertility. Erosion is a moderate hazard. The soils are—

Deschutes sandy loam, 2 to 6 percent slopes.
Deschutes sandy loam (2 to 6 percent slopes) (in DvB).
Deschutes sandy loam, moderately deep over gravel, 2 to 6 percent slopes.
Deschutes sandy loam, deep over basalt, 2 to 6 percent slopes.
Prineville sandy loam, 2 to 6 percent slopes.
Prineville gravelly sandy loam, 2 to 6 percent slopes.

These soils are well suited to irrigation, and all the common crops do well on them, but irrigation on the gentle slopes is slightly difficult. Suitable crop rotations for irrigated areas are (a) 1 or 2 years of potatoes, 1 year of small grain, and 5 years of alfalfa; (b) 1 or 2 years of small grain followed by 5 years of alfalfa or alfalfa-grass; and (c) 1 or 2 years of small grain and 2 years of Ladino clover for seed. Apply fertilizer according to needs indicated by soil tests.

For irrigating potatoes, contour furrows are most suitable because they help to control erosion and to conserve water. Alfalfa or other plants for hay and pasture, clover for seed, and small grain can be irrigated by use of corrugations, sprinklers, or controlled flooding from contour ditches. Border irrigation can be used for close-growing crops where slopes do not exceed 4 percent.

In dryland areas the soils of this unit are suitable only as range. Properly grazing the range only in spring and fall helps native plants maintain their vigor. Grasses suitable for reseeding are crested wheatgrass and Siberian wheatgrass (*9*).

CAPABILITY UNIT IIe-2

This unit consists of well-drained soils that are 42 to more than 60 inches deep and have a moderately coarse textured surface layer and a moderately coarse textured or medium-textured subsoil. Slopes range from 2 to 6 percent. These soils are moderately to rapidly permeable and have moderate moisture-holding capacity and fertility. The erosion hazard is moderate. The soils are—

Courtrock sandy loam, 2 to 6 percent slopes.
Courtrock gravelly sandy loam, 2 to 6 percent slopes.
Metolius sandy loam, 2 to 6 percent slopes.
Prineville sandy loam, thick surface, 2 to 6 percent slopes.

The Courtrock and Metolius soils have a substratum of porous sand or gravel; the Prineville soil has a hardpan underlying the subsoil.

These soils are well suited to irrigation, though their gentle slopes are slightly difficult to irrigate. In most places they are well suited to all crops grown in the survey area. The Prineville soil is particularly desirable for potatoes, but along the Dry River where frost is a hazard the Metolius soil is not suited to potatoes.

In irrigated areas the content of organic matter can be increased by using a suitable crop rotation. A satisfactory rotation is (a) 1 or 2 years of potatoes, 1 year of small grain, and 4 to 6 years of alfalfa; or (b) 1 or 2 years of small grain followed by 4 to 6 years of alfalfa or alfalfa-grass. Fertilizer should be applied according to needs indicated by soil tests.

Deep cuts can be made in these soils where leveling is needed to improve the management of irrigation water. Irrigating potatoes from contour furrows helps to control erosion and to conserve water. Small grain, as well as alfalfa or other plants grown for hay and pasture, can be irrigated by use of corrugations, sprinklers, or controlled flooding from contour ditches. On slopes of not more than 4 percent, these crops can also be irrigated by the border method.

In some areas the soils of this capability unit are dryfarmed to small grain, principally rye that is grown for livestock feed. If stubble-mulch tillage is used during the fallow period, a farming system of small grain alternated with summer fallow is effective in keeping soil losses to the minimum. Areas of native range in poor condition can be seeded to crested wheatgrass or Siberian wheatgrass. These dryland areas are highly suitable for irrigation, however, and could be used more intensively if water were available.

CAPABILITY UNIT IIe-3

In this capability unit are gently sloping, moderately deep, well-drained soils that have a medium-textured or moderately fine textured subsoil. Their surface layer is moderately coarse textured or medium textured. Slopes range from 2 to 6 percent. These soils have moderate or moderately slow permeability and moderate fertility and moisture-holding capacity. They are moderately susceptible to erosion. The soils are—

Deschutes sandy loam, moderately deep over hardpan, 2 to6 percent slopes.
Ochoco loam, 2 to 6 percent slopes.
Ochoco gravelly loam, 2 to 6 percent slopes.
Ochoco sandy loam, 2 to 6 percent slopes.
Ochoco sandy loam, 2 to 6 percent slopes (in AoB).
Ochoco gravelly sandy loam, 2 to 6 percent slopes.
Redmond sandy loam, 2 to 6 percent slopes.

These soils are well suited to irrigation, and to all crops grown locally, but irrigating the gentle slopes is slightly difficult. Crop rotations suitable for irrigated areas are (a) 1 or 2 years of potatoes, 1 year of small grain, and 4 to 6 years of alfalfa; (b) 1 or 2 years of small grain followed by 4 to 6 years of alfalfa or alfalfa-grass; and (c) 1 or 2 years of small grain followed by 4 to 6 years of Ladino clover and grass. Fertilize in amounts indicated by soil tests. Wind erosion can be controlled in irrigated fields by using suitable rotations and by keeping the soils moist during the windy period.

Because the soils of this unit are only moderately deep, care is needed in leveling to avoid cutting them so deeply that large areas are made shallow to the underlying hardpan or bedrock. For irrigating potatoes, contour furrows are most suitable because they help to control erosion and to conserve water. Small grain, alfalfa, and other plants for hay and pasture can be irrigated by use of corrugations, sprinklers, or controlled flooding from contour ditches or, where slopes do not exceed 4 percent, by use of borders.

In dryfarming areas a cropping system of small grain and summer fallow, together with stubble mulching during the fallow period, helps to control wind and water erosion. Suitable grasses for seeding range and other dryland areas are crested wheatgrass and Siberian wheatgrass. These areas could be used more intensively if irrigation water were available.

CAPABILITY UNIT IIe-4

This unit consists of nearly level or gently sloping, shallow to deep, well-drained soils that have a medium-textured or moderately coarse textured surface layer and a clay or clay loam subsoil. These soils have slow or moderately slow permeability. Their moisture-holding capacity and fertility range from low to high. Erosion is a moderate hazard. The soils are—

Lamonta loam, 0 to 6 percent slopes.
Lookout loam, 0 to 2 percent slopes.
Lookout loam, 2 to 6 percent slopes.
Polly loam, 0 to 6 percent slopes.
Polly gravelly loam, 0 to 6 percent slopes.
Polly sandy loam, 2 to 6 percent slopes.
Polly sandy loam, thick surface, 2 to 6 percent slopes.
Salisbury loam, 0 to 6 percent slopes.

The suitability of these soils for irrigation ranges from very good to fair, though much of the acreage occurs above existing canals. Because the soils have a fine textured or moderately fine textured subsoil, they are poorly suited to potatoes. They are well or moderately well suited to all other irrigated crops and to all dryland crops grown in the Area.

A suitable crop rotation for irrigated areas is 1 or 2 years of small grain followed by 4 to 6 years of alfalfa, alfalfa and grass, or Ladino clover and grass. Fertilizer should be applied in amounts indicated by soil tests. In fields of irrigated grasses and legumes for hay or pasture, heavy applications of nitrogen stimulate the grasses and tend to decrease the growth of legumes, whereas additions of phosphate and sulfur increase the growth of legumes.

These soils have a slow rate of water intake, particularly if leveling exposes the clayey subsoil. Suitable methods of irrigating alfalfa, other plants for hay and pasture, and small grain are corrugations, sprinklers, and controlled flooding from contour ditches.

In dryland fields where small grain is alternated with summer fallow, stubble mulching reduces erosion and conserves moisture. Soil losses are less if grain stubble is left standing through winter following harvest than if it is disturbed by plowing, disking, or sweeping. In fields where stubble is disturbed in fall, the soil should be left rough and cloddy through winter.

Suitable grasses for dryland areas of Lamonta and Lookout soils are crested wheatgrass, Siberian wheatgrass, and Whitmar beardless wheatgrass. A suitable dryland mixture for Polly and Salisbury soils is pubescent wheatgrass and alfalfa.

CAPABILITY UNIT IIe-5

This unit consists of shallow, well-drained soils that have a moderately coarse textured surface layer and a gravelly or cobbly loam or clay loam subsoil over a very hard, gravelly hardpan. Slopes range from 2 to 6 percent. These soils have moderately slow permeability in the subsoil. Their moisture-holding capacity and fertility are low. Under irrigation, the soils are moderately susceptible to erosion. They are—

Ayres sandy loam, 2 to 6 percent slopes.
Ayres sandy loam, 2 to 6 percent slopes (in AoB).
Ayres gravelly sandy loam, 2 to 6 percent slopes.

These soils are well suited to irrigation, but about half the acreage occurs above present canals. A small part of the dryland acreage is cultivated to rye for grain. The soils are well suited to grasses and legumes that are shallow rooted. A suitable rotation for irrigated areas is 1 or 2 years of small grain followed by 4 to 6 years of Ladino clover and grasses. Less suitable but satisfactory is a rotation consisting of potatoes for 1 or 2 years, small grain for 1 year, and alfalfa-grass for 4 to 6 years. Apply fertilizer according to needs indicated by soil tests.

Leveling these soils is difficult, for they are shallow and sloping. Water can be effectively applied to potatoes from contour furrows and to alfalfa, other plants for hay and pasture, and small grain by use of corrugations, sprinklers, or controlled flooding from contour ditches.

Although precipitation is low, dryland areas used for small grain generally receive enough moisture to fill the shallow root zone. Annual cropping is suitable for these areas and results in less erosion than a system of alternate grain and summer fallow. Grasses suitable for dryland seeding are crested wheatgrass and Siberian wheatgrass.

CAPABILITY UNIT IIe-6

The soils of this unit are nearly level and moderately well drained or well drained. These soils occur on alluvial flood plains and are occasionally flooded and subject to channeling and washing in spring. They are medium textured or moderately coarse textured from the surface to the gravel and sand substratum. Their permeability is moderate or moderately rapid, and their moisture-holding capacity and fertility range from low to very high, depending on thickness and texture of the soil. There is little or no erosion hazard. The soils are—

Powder fine sandy loam, coarse variant.
Powder fine sandy loam, over gravel, coarse variant.
Powder gravelly loam.
Powder silt loam.
Powder silt loam, over gravel.

These soils are well suited to irrigation, though they are easily overirrigated. They are poorly suited to potatoes but are well or moderately well suited to all the other crops grown locally under irrigation. Care is needed in irrigating alfalfa and other deep-rooted crops, for too much water lowers yields. A suitable rotation is 1 or 2 years of small grain followed by several years of alsike clover and grasses. Alfalfa or Ladino clover can be substituted for alsike clover in the rotation.

Where leveling is needed, deep cuts can safely be made in all the soils of this unit except those that are shallow to sand or gravel. Suitable kinds of irrigation are the border and the sprinkler methods. In addition, corrugations are suitable on slopes that exceed 1 percent.

CAPABILITY UNIT IIs-1

In this unit are nearly level, moderately deep, well-drained soils that have a moderately coarse textured surface layer and subsoil. These soils are rapid or moderately rapid in permeability and are low to moderate in moisture-holding capacity and fertility. Erosion is only a slight hazard. The soils are—

Deschutes sandy loam, 0 to 2 percent slopes.
Deschutes sandy loam (0 to 2 percent slopes) (in DvB).
Deschutes sandy loam, moderately deep over gravel, 0 to 2 percent slopes.
Deschutes sandy loam, deep over basalt, 0 to 2 percent slopes.
Prineville sandy loam, 0 to 2 percent slopes.

These soils are well suited to irrigation, and all the common crops do well on them. Suitable rotations for irrigated areas are (a) 1 or 2 years of potatoes, 1 year of small grain, and 4 to 6 years of alfalfa or Ladino clover grown alone or in mixture with grass; and (b) 1 or 2 years of small grain followed by 4 to 6 years of alfalfa or Ladino clover and grass. Fertilizer should be applied according to needs indicated by soil tests.

Furrows are suitable for irrigating potatoes and, if slopes are greater than 1 percent, the furrows should be on the contour so that erosion is controlled and water is conserved. For irrigating alfalfa, other hay plants, pasture, and small grain, suitable methods are borders and sprinklers. On slopes exceeding 1 percent, corrugations also are used.

In dryland areas the soils of this unit are suited only to plants used for grazing. Crested wheatgrass and Siberian wheatgrass are satisfactory for seeding.

CAPABILITY UNIT IIs-2

This unit consists of nearly level, well-drained soils that occupy alluvial fans and are 42 to more than 60 inches deep. These soils have a moderately coarse textured surface layer. Their permeability is moderate or moderately rapid, and their moisture-holding capacity and fertility are moderate. The soils are only slightly susceptible to erosion. They are—

Courtrock gravelly sandy loam, 0 to 2 percent slopes.
Prineville sandy loam, thick surface, 0 to 2 percent slopes.

The Courtrock soil has a moderately coarse textured or medium-textured subsoil and a lower substratum of porous sand or gravel. The Prineville soil has a coarse textured or moderately coarse textured subsoil but is underlain by a hardpan over softly consolidated, tuffaceous sandstone.

These are good soils for irrigation, and they are well suited to all crops grown in the Area. Because of its gravelly surface layer, the Courtrock soil is less desirable for potatoes than the Prineville soil. Suitable rotations are (a) 1 or 2 years of potatoes, 1 year of small grain, and 4 to 6 years of alfalfa or Ladino clover planted alone or in mixture with grass; and (b) 1 or 2 years of small grain followed by 4 to 6 years of a legume or a grass-legume mixture. Fertilize in amounts indicated by soil tests.

The soils of this unit are deep enough for leveling cuts to be made as needed to improve the spread of irrigation water. For irrigating potatoes, furrows should be on the contour if slopes are greater than 1 percent. Small grain, as well as alfalfa and other plants used for hay or pasture, can be irrigated by use of borders or sprinklers or, on slopes of more than 1 percent, by use of corrugations.

In most places wind erosion can be controlled if the soil surface is protected with crop residues or sod and if bare areas are kept moist during the windy season.

In dryfarming areas where small grain is alternated with summer fallow, stubble-mulch tillage keeps erosion to the minimum. Grasses suitable for seeding dryland soils are crested wheatgrass and Siberian wheatgrass. All of these areas could be used more intensively if irrigation water were available.

CAPABILITY UNIT IIs-3

This unit consists of nearly level, well-drained soils that have a moderately coarse textured or medium-textured surface layer and a medium-textured or moderately fine textured subsoil or substratum. These soils generally are moderately deep and have moderate or moderately slow permeability. They are moderate in fertility and moisture-holding capacity. Erosion is only a slight hazard. The soils are—

Deschutes sandy loam, moderately deep over hardpan, 0 to 2 percent slopes.
Deschutes sandy loam, deep over hardpan, 0 to 2 percent slopes.
Ochoco loam, 0 to 2 percent slopes.
Ochoco gravelly sandy loam, 0 to 2 percent slopes.
Ochoco gravelly sandy loam, 0 to 2 percent slopes (in ArA).
Ochoco sandy loam, 0 to 2 percent slopes.
Ochoco sandy loam, 0 to 2 percent slopes (in AoA).
Redmond loam, 0 to 2 percent slopes.
Redmond sandy loam, 0 to 2 percent slopes.

The deep Deschutes soil is rapidly permeable but is underlain by a very slowly permeable hardpan at a depth of 42 to 54 inches.

The soils of this unit are well suited to irrigation, and all crops common in the Area can be grown successfully on them. Suitable rotations for these soils are the same as those for the soils in capability unit IIs–2. Fertilizer should be applied in amounts indicated by soil tests.

These soils can be leveled as needed for efficient irrigation. Suitable methods of irrigating are the same as those listed for the soils in unit IIs–1.

Wind erosion is controlled in irrigated areas by leaving crop residues on the surface, establishing a sod cover, or keeping bare fields moist during the windy months. Stubble-mulch tillage reduces erosion in dryfarmed areas. Suitable grasses for dryland seeding are crested wheatgrass and Siberian wheatgrass. A large acreage of soils in this unit cannot be used more intensively, because irrigation water is not now available.

CAPABILITY UNIT IIs-4

This unit consists of shallow, nearly level, well-drained soils that have a moderately coarse textured surface layer and a gravelly or cobbly loam or clay loam subsoil underlain by a gravelly hardpan. In these soils permeability is moderately slow. The moisture-holding capacity and fertility are low. Erosion is only a slight hazard. The soils are—

Ayres sandy loam, 0 to 2 percent slopes (in AoA).
Ayres gravelly sandy loam, 0 to 2 percent slopes (in ArA).

These are good soils for irrigation. They are best suited to shallow-rooted crops but are well or moderately well suited to all crops grown locally. Rotations like those listed for capability unit IIe–5 can be used successfully on these soils. Apply fertilizer according to needs indicated by soil tests.

The soils in this unit are difficult to level because they are shallow. Suitable methods of irrigation are furrows for potatoes and sprinklers, corrugations, and controlled flooding from contour ditches for small grain, hay crops, and pasture.

A small acreage of these soils is dryfarmed, principally to rye for hay. Normally, precipitation is sufficient for annual cropping, but occasionally a year of fallow is necessary. In years when the soil is fallowed, stubble-mulch tillage aids in controlling erosion. Suitable grasses for dryland areas are crested wheatgrass and Siberian wheatgrass.

CAPABILITY UNIT IIs-5

The soils in this unit are deep, nearly level, and well drained. These soils occur on flood plains and alluvial fans. They are moderately coarse textured or medium textured in the surface layer and the subsoil, and they are moderately to rapidly permeable. The soils are—

Courtrock sandy loam, 0 to 2 percent slopes.
Metolius loam, 0 to 2 percent slopes.
Metolius sandy loam, 0 to 2 percent slopes.

These soils are well suited to irrigation and, in most places, all the common crops do well on them. In the Dry Creek area, however, potatoes do not grow well on Metolius soils, because frost is a hazard, and in the Lone Pine area some Metolius loam has a high water table that limits the growth of alfalfa.

The soils in this unit have a naturally low supply of organic matter that can be increased by using a rotation in which row crops are grown for 1 or 2 years; wheat, barley, or oats for 1 year; and alfalfa for 4 to 6 years. A mixture of alfalfa and grass or Ladino clover and grass can be substituted for alfalfa in the rotation. Also suitable is a rotation consisting of 2 years of small grain followed by 4 to 6 years of alfalfa, alfalfa and grass, or Ladino clover and grass. Fertilizer should be applied in amounts indicated by soil tests.

The soils of this unit are deep and can be leveled as needed for good management of irrigation water. Furrow irrigation is desirable for potatoes and, where slopes exceed 1 percent, the furrows should be on the contour. Borders or sprinklers are used with small grain, hay crops, and pasture. These crops also can be irrigated by use of corrugations if slopes are more than 1 percent.

CAPABILITY UNIT IIc-1

This unit consists of nearly level, deep, well-drained soils on flood plains. These soils are medium textured or moderately coarse textured in the surface layer and the subsoil. Their permeability is moderate, and their moisture-holding capacity and fertility are high. The risk of erosion is only slight. The soils are—

Powder loam.
Powder sandy loam.

These soils are well suited to irrigation, and all crops common in the Area can be grown successfully on them (fig. 5).

Although the organic-matter content is naturally low in these soils, it can be increased by using a rotation consisting of 1 or 2 years of row crops, 1 year of small grain, and 4 to 6 years of alfalfa. Small grains suitable in the rotation are wheat, barley, and oats. A mixture of alfalfa and grass or of Ladino clover and grass can be substituted for the alfalfa. Another satisfactory rotation is 2 years of small grain followed by 4 to 6 years of alfalfa, grass and alfalfa, or grass and Ladino clover. Fertilizer should be applied according to needs indicated by soil tests.

The soils of this unit are deep enough for heavy cuts to be made in areas where leveling is needed to improve irrigation. Furrows are most suitable for irrigating potatoes, preferably on the contour if slopes exceed 1 percent. Borders or sprinklers are good methods of irrigation for small grain and for alfalfa and other crops grown for hay or pasture, but corrugations can be used on slopes greater than 1 percent.

CAPABILITY UNIT IIIe-1

This unit consists of well-drained, moderately coarse textured soils that occupy slopes of 6 to 12 percent and are 18 to 42 inches deep. In these soils permeability is rapid or moderately rapid, and the moisture-holding capacity and fertility are moderate. Erosion is a severe hazard. The soils are—

Deschutes sandy loam, 6 to 12 percent slopes.
Prineville sandy loam, 6 to 12 percent slopes.

These soils are fairly suitable for irrigation, though they are difficult to irrigate because of slope. They are poorly suited to potatoes and other row crops but are moderately well or well suited to other crops grown in the survey area. Suitable rotations are (a) 1 or 2 years of small grain followed by 4 to 6 years of alfalfa or alfalfa-grass; and (b) 1 or 2 years of grain and 4 to 6 years of Ladino clover and grass. Fertilize in amounts indicated by soil tests. Sprinkler irrigation is best for irrigating small grain, grasses, and legumes.

In dryland areas the soils are suited only as range. To help native plants maintain their vigor, limit grazing to spring and fall. Crested wheatgrass and Siberian wheatgrass are suitable for dryland seeding.

CAPABILITY UNIT IIIe-2

In this unit are well-drained, sloping soils that are 42 to more than 60 inches deep. Slopes range from 6 to 12 percent. These soils have a moderately coarse textured surface layer and a moderately coarse textured or medium-textured subsoil. Permeability ranges from moderate to rapid, and the moisture-holding capacity and fertility are moderate. The erosion hazard is moderate or severe. The soils are—

Courtrock sandy loam, 6 to 12 percent slopes.
Courtrock gravelly sandy loam, 6 to 12 percent slopes.
Metolius sandy loam, 6 to 12 percent slopes.
Prineville sandy loam, thick surface, 6 to 12 percent slopes.

In the Prineville soil, a fine sandy loam to loamy sand subsoil is underlain by a hardpan. The other soils have a substratum of porous sand or gravel.

Because the soils in this unit are sloping, they are difficult to irrigate, and their suitability for irrigation is only fair. The soils are best used for pasture. They are moderately well suited to alfalfa and small grain but are poorly suited to potatoes. Adequate rotations are (a) 1 or 2 years of small grain followed by 4 to 6 years of alfalfa alone or in mixture with grass; and (b) 1 or 2 years of small grain and 4 to 6 years of Ladino clover and grass. Fertilizer should be applied according to needs indicated by soil tests.

Sprinklers are most suitable for irrigating small grain, legumes, and grasses, but controlled flooding from contour ditches can be used if slopes do not exceed 8 percent.

Some areas of these soils are dryfarmed to small grain. A farming system of grain alternated with summer fallow is effective in minimizing soil losses where stubble mulching is used during the fallow perod. Crested wheatgrass and Siberian wheatgrass are suitable for seeding dryland areas.

CAPABILITY UNIT IIIe-3

This unit consists of shallow to deep, well-drained soils that have a moderately coarse textured or medium-textured surface layer over a medium-textured or moderately fine textured subsoil. The slopes are 6 to 12 percent. In these soils permeability is moderate or moderately slow, and the moisture-holding capacity and fertility range from low to high. Erosion is a moderate or severe hazard. The soils are—

Ayres sandy loam, 6 to 12 percent slopes.
Ayres sandy loam, 6 to 12 percent slopes (in AoC).
Deschutes sandy loam, moderately deep over hardpan, 6 to 12 percent slopes.
Ochoco sandy loam, 6 to 12 percent slopes.
Ochoco sandy loam, 6 to 12 percent slopes (in AoC).
Ochoco gravelly sandy loam (6 to 12 percent slopes) (in ArD).
Polly loam, 6 to 12 percent slopes.
Polly gravelly loam, 6 to 12 percent slopes.
Polly sandy loam, thick surface, 6 to 12 percent slopes.

These sloping soils are difficult to irrigate, and their suitability for irrigation is only fair. Although the soils are poorly suited to potatoes and other row crops, they are moderately well or well suited to other crops commonly grown. Suitable rotations are (a) 1 or 2 years of small grain followed by 4 to 6 years of alfalfa or alfalfa and grass; and (b) 1 or 2 years of small grain and 4 to 6 years of Ladino clover and grass. Fertilizer should be applied in amounts indicated by soil tests.

Except for the Polly soils, these soils are difficult to level because of their slope and restricted depth. In Polly soils the cuts can be deeper, though leveling is somewhat limited by slope. Small grain, legumes, and grasses are best irrigated through sprinklers, but they can be irrigated by controlled flooding from contour ditches if slopes do not exceed 8 percent.

Wind erosion in irrigated areas can be reduced by using suitable crop rotations and by keeping the soil moist during the windy season. In dryland areas stubble mulching helps to control blowing and washing. Plants suitable for seeding range and dryland fields are pubescent wheatgrass and alfalfa on the Polly soils and crested wheatgrass and Siberian wheatgrass on the other soils.

***Figure 5.*—Powder loam, if irrigated, is well suited to all crops grown in the Prineville Area. Behind the trees is a terrace escarpment separating the Powder soil from an area of Ochoco and Prineville soils. Barnes Butte (upper left) is occupied mainly by the Searles soils.**

CAPABILITY UNIT IIIe-4

Soils in this unit are well drained and are 12 to 30 inches deep over a gravelly hardpan. They have a medium-textured or moderately coarse textured surface layer and a medium- to fine-textured subsoil. Permeability is moderately slow or slow, and the moisture-holding capacity and fertility are low. The soils are moderately or severely erodible if not protected. They are—

Ayres gravelly sandy loam, 6 to 12 percent slopes.
Ayres gravelly sandy loam (6 to 12 percent slopes) (in ArD).
Lamonta gravelly loam, 6 to 12 percent slopes.

The sloping soils are fairly suitable for irrigation, but they are difficult to irrigate. Because the rooting zone is limited by hardpan in the Ayres soils and by a clay subsoil in the Lamonta soil, the soils of the unit are best suited to shallow-rooted plants used for pasture. They are moderately well suited to small grain and, for the most part, to plants grown for hay and pasture, but the Lamonta soil is poorly suited to alfalfa. All the soils are poorly suited to potatoes and other row crops.

A good rotation is 1 or 2 years of small grain followed by 5 or 6 years of Ladino clover and grass. Fertilizer should be applied according to needs indicated by soil tests. On seedings of irrigated hay or pasture, heavy applications of nitrogen stimulate the grasses and thereby tend to decrease the growth of legumes, whereas additions of phosphate and sulfur increase the growth of legumes.

If these soils are leveled, cuts should be made carefully because the depth of usable soil is limited. Sprinkler irrigation is most suitable, but water can be applied by controlled flooding from contour ditches if slopes are not more than 8 percent. Suitable grasses for dryland seedings are crested wheatgrass and Siberian wheatgrass.

CAPABILITY UNIT IIIw-1

In this unit are moderately deep or deep, well-drained to poorly drained soils that occur on flood plains or in low areas on terraces and have a high water table during much of the growing season. Permeability is moderate or moderately slow in these soils. The moisture-holding capacity and fertility are moderate to high. There is little or no erosion hazard. The soils are—

Boyce loam, light-colored variant.
Boyce silt loam.
Boyce silty clay loam.
Ochoco sandy loam, seeped, 0 to 2 percent slopes.

Some areas of these soils are slightly affected by alkali, and the lowest areas of the Boyce soils are subject to flooding in spring.

The soils of this unit are best suited to grasses and legumes for hay and pasture. Meadow foxtail and alsike clover make up a good mixture for inadequately drained areas. Unless drainage is improved, the soils are poorly suited to potatoes and alfalfa. If they are drained and leveled, however, and if alkali areas are improved by leaching and applying gypsum or sulfur, these soils produce high yields of alfalfa and are suited to a rotation of small grain followed by alfalfa or alfalfa-grass or by a mixture of Ladino clover and grass.

If the soils are drained and alkali is removed, suitable kinds of irrigation are the border and the sprinkler methods. On slopes of more than 1 percent, water can be safely applied by use of corrugations. In undrained areas irrigation is generally not needed, though crops may benefit from water added by sprinkling.

CAPABILITY UNIT IIIw-2

This unit consists of imperfectly drained, pumiceous, mainly sandy soils that are affected by alkali. These soils contain an excessive amount of sodium, and generally they are very strongly alkaline. Their fertility and moisture-holding capacity are low to moderate. Erosion is a slight or moderate hazard. The soils are—

Crooked loam, 0 to 2 percent slopes.
Crooked loam (in Sm).
Crooked loamy sand, 0 to 2 percent slopes.
Crooked sandy loam, 0 to 2 percent slopes.
Crooked sandy loam, 2 to 6 percent slopes.
Forester loamy sand.
Forester sandy loam.

The Crooked soils are shallow or moderately deep to hardpan, and the Forester soils are deep.

The soils of this unit are best used for hay or pasture. Unless they are reclaimed, however, they are suited only to plants that tolerate alkali. If drainage is improved and the soils are leveled, the alkali content can be lowered by applying manure or other organic matter, using gypsum or sulfur, and leaching with large amounts of water. After reclamation, a suitable crop rotation is 1 or 2 years of small grain followed by 5 or 6 years of strawberry clover mixed with alta fescue or meadow foxtail. Alfalfa alone or alfalfa and grass can be substituted for the clover-grass mixture. Also suitable is any rotation that keeps the soils in hay or pasture most of the time.

Reclamation is easiest on the Forester soils and is most difficult and most expensive on Crooked loam. Reclaiming the Crooked soils is hastened if the pan is broken by chiseling, but adequate amounts of irrigation water are needed to keep salts and alkali from accumulating in the surface layer. Level basins, level borders, or sprinklers are generally used for small grain and for pasture and hay crops, but on Crooked sandy loam, 2 to 6 percent slopes, irrigating through sprinklers or by controlled flooding gives the best results. Where reclamation is inadequate or irrigation water is limited, tall wheatgrass is an alkali-tolerant grass well suited to hay or pasture.

CAPABILITY UNIT IIIs-1

The soils in this unit are nearly level or gently sloping, moderately deep or deep, and well drained or somewhat excessively drained. These soils have upper layers of pumiceous loamy sand. They are low to moderate in moisture-holding capacity and fertility. The soils are—

Deschutes loamy sand, 0 to 2 percent slopes.
Deschutes loamy sand, 2 to 6 percent slopes.
Deschutes loamy sand, moderately deep over hardpan, 0 to 2 percent slopes.
Deschutes loamy sand, moderately deep over hardpan, 2 to 6 percent slopes.
Metolius loamy sand, 0 to 2 percent slopes.
Metolius loamy sand, 2 to 6 percent slopes.
Ochoco loamy sand, 2 to 6 percent slopes.

These soils have fair to good suitability for irrigation; they are well suited to all irrigated crops grown in the Area. A suitable rotation is (a) 1 year of potatoes, 1 year of small grain, and 4 to 6 years of alfalfa or alfalfa and grass; or (b) 1 year of small grain followed by 4 to 6 years of Ladino clover and grass. Fertilizer should be applied according to needs indicated by soil tests.

Potatoes can be irrigated by use of sprinklers or furrows on slopes of less than 1 percent and by contour furrows on slopes between 1 and 4 percent. Grain, hay crops, and pasture can be irrigated through sprinklers or by controlled flooding from contour ditches. In addition, borders are suitable if slopes do not exceed 2 percent.

To control wind erosion in irrigated fields, carefully rotate crops, maintain crop residues on the surface, use minimum tillage, and keep the soil moist during windy periods. In areas of dryland farming, wind erosion is kept to the minimum if the soils are stubble mulched and if alternate strips of grain and fallow are laid out across the prevailing wind. Suitable grasses for seeding dryland areas are crested wheatgrass and Siberian wheatgrass.

CAPABILITY UNIT IIIs-2

This unit consists of well-drained or somewhat excessively drained soils that are 18 to more than 60 inches deep. These soils occupy flood plains and alluvial fans in high, narrow valleys where the growing season is short and the hazard of frost is severe. They have low to moderate fertility and moderate or moderately rapid permeability. Their moisture-holding capacity ranges from low to moderate, depending on depth and texture. The erosion hazard is none to moderate. These soils are—

Steiger sandy loam.
Veazie loam.
Veazie loam (in Vr).
Veazie loam, shallow.
Veazie gravelly loam.

These soils generally are nearly level, but some areas of the Steiger soil are gently sloping.

The soils of this unit are well suited to irrigation. In most places, however, use is limited mainly to hay and pasture because frost is a hazard. Small grain can be used in reestablishing stands of alfalfa, alfalfa and grass, or

Ladino clover and grass. Fertilizer should be applied in amounts indicated by soil tests. Suitable methods of irrigation are by borders, corrugations, sprinklers, and controlled flooding from contour ditches.

CAPABILITY UNIT IVe-1

This unit consists of shallow to deep, well-drained soils that have moderately slow to rapid permeability. Slopes range from gentle to moderately steep. These soils are low to moderate in fertility and moisture-holding capacity. Under irrigation, they are subject to moderate or severe erosion. The soils are—

Ayres sandy loam, 12 to 20 percent slopes (in AoD).
Ayres gravelly sandy loam (12 to 20 percent slopes) (in ArD).
Metolius sandy loam, 12 to 20 percent slopes.
Ochoco sandy loam, 12 to 20 percent slopes (in AoD).
Ochoco gravelly sandy loam (12 to 20 percent slopes) (in ArD).
Prineville gravelly sandy loam, 6 to 20 percent slopes.
Slayton sandy loam, 2 to 20 percent slopes.
Slayton sandy loam, 2 to 20 percent slopes (in SfD).

These soils are fair to very poor for irrigation. Their best use is range or irrigated pasture. In many places the Ayres, Ochoco, and Prineville soils have short slopes. Most of the Metolius soil occurs above existing irrigation canals.

For irrigated pasture a mixture of Ladino clover and alta fescue or orchardgrass can be used, and the best method of irrigation is sprinklers. Grasses suitable for seeding dryland areas are crested wheatgrass and Siberian wheatgrass.

CAPABILITY UNIT IVw-1

The only soil in this unit, Swartz silt loam, occurs in basins that have no outlet and is imperfectly drained. It has a clay or silty clay subsoil that seals tightly when wet and cracks as it dries. Runoff is very slow, and there is no erosion hazard. The soil is slowly permeable and has low moisture-holding capacity and fertility.

Most of this soil is not cultivated. The lowest areas can be used for crops if excess water is removed by ditching or pumping. Suitable rotations are (a) 1 or 2 years of potatoes, 1 year of small grain, and 4 to 6 years of alfalfa and grass; and (b) 1 or 2 years of small grain followed by 4 to 6 years of Ladino clover and grass. Fertilize according to needs indicated by soil tests.

Furrows or sprinklers are suitable for irrigating potatoes. Borders or sprinklers are suitable for small grain, hay crops, and pasture, but corrugations or controlled flooding from contour ditches also can be used where slopes are more than 1 percent.

CAPABILITY UNIT IVw-2

Only Ontko clay loam and clay are in this unit. They are deep, poorly drained, and moderately fine textured or fine textured in the surface layer and subsoil. In spring they are frequently flooded, but there is little or no erosion hazard. Permeability is moderately slow or slow, fertility is high, and the moisture-holding capacity is very high.

These soils are difficult or very difficult to work because they are clayey and wet. Ditches or tile lines are needed to improve drainage. Pasture or hay crops are best suited, but small grain can be used as a companion crop in establishing stands of hay or pasture. A suitable mixture consists of alsike clover and meadow foxtail or alta fescue. Fertilizer should be applied according to needs indicated by soil tests.

Borders and sprinklers are suitable methods of irrigation. In addition, slopes of more than 1 percent can be irrigated by use of corrugations or controlled flooding from contour ditches.

CAPABILITY UNIT IVw-3

The only soil in this unit, Stearns silt loam, is mapped alone and also in the Stearns-Crooked complex (Sm). This soil is imperfectly drained and slowly permeable. It has a silty clay loam subsoil underlain by a cemented hardpan at a depth of 12 to 30 inches. The soil contains excess sodium, in most places is very strongly alkaline, and puddles and seals over when wet. This interferes with the germination of seeds and the emergence of seedlings (fig. 6). The root zone is shallow, and the water-holding capacity and fertility are low. Erosion is only a slight hazard.

This soil is naturally affected by alkali, some areas more strongly than others. Greasewood and patches of saltgrass generally make up the plant cover on areas that contain the most alkali. Reclaiming these areas may not be feasible, but seeding them to tall wheatgrass is desirable. To obtain a good stand of grass, seedings should be made when the surface layer has a favorable content of moisture.

Areas less strongly affected by alkali can be reclaimed and used for crops if adequate drainage is provided. Other practices needed are leveling, leaching with a large amount of water, applying manure or other organic matter, using gypsum or sulfur, and fertilizing according to needs indicated by soil tests. Reclamation requires a large supply of good water. For reclaimed areas suitable crops are pasture, alfalfa, and small grain; suitable methods of applying water are border and sprinkler irrigation.

CAPABILITY UNIT IVs-1

In this unit are pumiceous loamy sands that are sloping to moderately steep, moderately deep to very deep, and somewhat excessively drained. These soils have very rapid permeability and are low in moisture-holding capacity and fertility. The erosion hazard is severe. The soils are—

Deschutes loamy sand, 6 to 20 percent slopes.
Metolius loamy sand, 6 to 12 percent slopes.

Because of slope and coarse texture, these soils have poor to fair suitability for irrigation. They are best suited to irrigated pasture or range. If water is applied through sprinklers, however, the soils are suited to a rotation of small grain and alfalfa or alfalfa and grass. Sprinkler irrigation can also be used in establishing pasture of Ladino clover and grass. For irrigating well-sodded pasture, controlled flooding from contour ditches can be used.

Fertilizer should be applied in amounts indicated by soil tests. To help control wind erosion, keep bare areas moist during the windy season. Crested wheatgrass and Siberian wheatgrass are suitable for seeding dryland areas.

CAPABILITY UNIT IVs-2

This unit is made up of shallow to deep, well-drained or somewhat excessively drained stony soils on slopes of 0 to 6 percent. Because these soils are stony, they are difficult to work. They have very rapid to moderately slow permeability, and their moisture-holding capacity

Figure 6.—Stearns silt loam is affected by alkali and is difficult to reclaim. The surface puddles and seals over when wet. As the soil dries, cracks form in the surface layer and even in the subsoil.

and fertility are low to moderate. Runoff causes a slight to moderate hazard of erosion. The soils are—

Ayres stony sandy loam, 0 to 6 percent slopes.
Ayres stony sandy loam, 0 to 6 percent slopes (in AsB).
Courtrock stony sandy loam, 2 to 6 percent slopes.
Deschutes stony loamy sand, 0 to 6 percent slopes.
Deschutes stony sandy loam, 0 to 2 percent slopes.
Deschutes stony sandy loam, 2 to 6 percent slopes.
Ochoco stony sandy loam, 0 to 6 percent slopes (in AsB).
Redmond stony loam, 0 to 6 percent slopes.
Redmond stony sandy loam, 0 to 6 percent slopes.

Under irrigation these soils are best suited to pasture, but they also are suited to hay, though stones interfere with harvesting. Suitable plants are Ladino clover, alfalfa, and grass. A small grain can be used as a companion crop in establishing stands of pasture or hay. Suitable methods of irrigation are the sprinkler method and controlled flooding from contour ditches.

In dryland areas crested wheatgrass and Siberian wheatgrass can be grown on these soils.

CAPABILITY UNIT Vw-1

In this unit are very poorly drained soils in depressional areas that have water on or near the surface during much of the year. These soils are moderately slow or slow in permeability, but they are highly fertile and have high or very high moisture-holding capacity. Root growth is moderately deep or deep. Erosion is not a problem. The soils are—

Boyce silt loam, ponded.
Ontko clay loam, ponded.

Draining these soils is generally not feasible, because of their low position. Reed canarygrass or other water-tolerant grasses of high forage value can be grown if culms are planted.

CAPABILITY UNIT VIe-1

This unit consists of nearly level to steep, well-drained, stony or channery soils that are shallow to deep over bedrock or hardpan. Permeability is rapid to slow, and the moisture-holding capacity and fertility are low. Erosion is a slight to severe hazard. The soils are—

Ayres gravelly sandy loam, 20 to 40 percent slopes (in ArE).
Ayres stony sandy loam, 6 to 20 percent slopes.
Courtrock stony sandy loam, 6 to 20 percent slopes.
Deschutes stony sandy loam, 6 to 20 percent slopes.
Lamonta stony loam, 6 to 20 percent slopes.
Lookout stony loam, 0 to 6 percent slopes.
Lookout stony loam, 6 to 20 percent slopes.
Ochoco gravelly sandy loam, 20 to 40 percent slopes (in ArE).
Searles stony loam, 2 to 20 percent slopes.
Searles stony loam, 6 to 40 percent slopes (in GgE).
Searles stony loam, 20 to 40 percent slopes.
Searles stony clay loam, 6 to 20 percent slopes.
Searles stony sandy loam, 6 to 20 percent slopes.
Searles stony sandy loam, 2 to 20 percent slopes (in SfD).
Searles stony sandy loam, 20 to 40 percent slopes.
Searles stony sandy loam, 20 to 40 percent slopes (in SfE).
Slayton channery sandy loam, 2 to 20 percent slopes.
Slayton channery sandy loam, 20 to 40 percent slopes.
Slayton channery sandy loam, 20 to 40 percent slopes (in SfE).

These soils are not suitable for irrigation or for dry-farming. In undisturbed areas the plant cover consists mainly of bluebunch wheatgrass, Sandberg bluegrass, needlegrass, sagebrush, and juniper. If range or pasture is properly managed, grazing is limited to spring and fall. In places where reseeding is needed, crested wheatgrass and Siberian wheatgrass are suitable.

CAPABILITY UNIT VIe-2

This unit consists of shallow to deep, well-drained, stony soils that have a clayey subsoil. Slopes range from 6 to 40 percent. These soils have slow to rapid runoff and are moderately or highly susceptible to erosion. Permeability is moderately slow, and the moisture-holding capacity and fertility are low to moderate. The soils are—

Gem stony loam, 6 to 20 percent slopes.
Gem stony loam, 6 to 40 percent slopes (in GgE).
Gem stony clay loam, 12 to 40 percent slopes (in GcE).
Polly stony loam, 6 to 20 percent slopes.

These soils are not suitable for irrigation farming. If undisturbed, the native plant cover consists mainly of Idaho fescue, bluebunch wheatgrass, bitterbrush, and sagebrush. On properly managed range or pasture, grazing is limited to spring and fall, but the period of use in spring is later on these soils than on the soils in capability unit VIe-1. Plants suitable for seeding are pubescent wheatgrass and alfalfa.

CAPABILITY UNIT VIIs-1

This unit consists mainly of nearly level to steep, shallow or moderately deep soils that are very stony or very rocky and are well drained. On these soils runoff is very slow to rapid, permeability is moderate to slow, and the erosion hazard is slight to severe. The moisture-holding capacity and fertility are low to moderate. The soils are—

Agency very stony sandy loam, 6 to 40 percent slopes.
Day clay, 6 to 40 percent slopes.
Day clay, 12 to 40 percent slopes (in GcE).
Lookout very stony loam, 0 to 40 percent slopes.
Redmond very stony sandy loam, 6 to 12 percent slopes.
Rock land.

These soils are not suited to cultivated crops and are not well suited to seeded grasses. Carefully managing the native plants is the best way to maintain or to improve the condition of range (fig. 7). In undisturbed areas the plant cover is dominantly bluebunch wheatgrass, Sandberg bluegrass, sagebrush, and juniper. On north-facing slopes Idaho fescue is abundant, and the proper season of use is late in spring and in fall. Other slopes are properly used if grazed carefully in spring and fall.

CAPABILITY UNIT VIIs-2

This unit consists of nearly level to moderately steep, well-drained or somewhat excessively drained soils that are 6 to 24 inches deep. These soils are very stony and commonly are called scabland. Slopes range from 0 to 20 percent but are 0 to 6 percent in most places. Permeability is rapid to moderately slow, fertility is low, and the moisture-holding capacity is low or very low. Erosion is a slight or moderate hazard. The soils are—

Bakeoven very stony loam, 0 to 20 percent slopes.
Bakeoven very stony sandy loam, 0 to 20 percent slopes.
Bakeoven very stony sandy loam, 0 to 6 percent slopes (in DuB).
Bakeoven very stony sandy loam, 0 to 6 percent slopes (in DvB).
Deschutes very stony sandy loam, 0 to 6 percent slopes (in DuB).

These soils are too stony and generally too shallow for cultivation. In places, however, they are used for pasture made up of volunteer stands of white clover and bluegrass that are irrigated by wild flooding. In other areas the plant cover is sparse and consists mostly of Sandberg bluegrass, juniper, and sagebrush. Reseeding these soils is impractical.

CAPABILITY UNIT VIIs-3

This unit consists of well-drained, stony or very stony soils that are very steep or severely eroded and, in places, have outcrops of rock. Slopes range from 20 to 70 percent. These soils have rapid or very rapid runoff and are highly susceptible to erosion. Permeability is slow, and the moisture-holding capacity and fertility are low. The soils are—

Agency very stony sandy loam, 40 to 70 percent slopes.
Searles stony clay loam, 20 to 40 percent slopes, severely eroded.

These soils are too stony and too steep for cultivation or reseeding. The plant cover consists chiefly of bluebunch wheatgrass, Sandberg bluegrass, sagebrush, and juniper, but on north- and east-facing slopes there is nearly as much Idaho fescue as wheatgrass. The soils are suitable for grazing, mainly late in spring and in fall, though their use is limited.

CAPABILITY UNIT VIIs-4

The soils in this unit are nearly level to steep, shallow to deep, and very stony. They have very slow to rapid runoff, moderately slow or slow permeability, and low to moderate moisture-holding capacity and fertility. The erosion hazard is slight to severe. The soils are—

Elmore very stony loam, 6 to 40 percent slopes.
Gem very stony loam, 6 to 40 percent slopes.
Salisbury very stony loam, 0 to 6 percent slopes.
Salisbury very stony loam, 6 to 20 percent slopes.

Figure 7.—**Native bunchgrasses on an area of Rock land and Deschutes soil.**

These soils are not suited to cultivated crops and are not well suited to seeded plants. The condition of range can best be maintained or improved by properly managing the native vegetation. In undisturbed areas the plant cover is dominantly Idaho fescue, bluebunch wheatgrass, bitterbrush, sagebrush, and juniper. On north-facing slopes, the plants can be safely grazed late in spring and in summer and fall. On other slopes the vegetation is ready for grazing late in spring and in fall.

CAPABILITY UNIT VIIIs-1

This unit consists of land types that are barren in most places. They are—

Borrow pits.
Riverwash.
Riverwash (in Vr).
Rock outcrop.

Shrubs, grasses, and a few trees grow in places on Riverwash.

The land types and soils in this unit have little or no agricultural value. They are used as a source of materia for roads, dams, and other construction.

Estimated Yields

Table 1 gives the estimated average acre yields of the principal crops grown in the Prineville Area under two levels of management. In columns A are yields that can be expected under average management. In columns B are yields that can be expected under the highest level of management that is now feasible.

These estimates are only for the soils that are suitable for cultivated crops under irrigation. The estimates are averages over a period of years, not yields for any particular year. They are based on observations made during the soil survey and on information obtained from farmers, the county agricultural agent, the Soil Con-

TABLE 1.—*Estimated average acre yields of principal crops under two levels of management*

[Yields in columns A are those expected over a period of years under average management; those in columns B, under the best management practical. Absence of yield indicates that crop is not grown under management specified or is not suited to the soil]

Soil	Alfalfa		Potatoes		Clover for seed		Winter wheat (irrigated)		Spring wheat (irrigated)		Barley (irrigated)		Seeded pasture (irrigated)	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Tons	*Tons*	*Bu.*	*Bu.*	*Lbs.*	*Lbs.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*
Ayres gravelly sandy loam, 0 to 2 percent slopes	2.5	4	300	400	400	900	40	60	30	50	50	70	2.3	4
Ayres gravelly sandy loam, 2 to 6 percent slopes	2.5	4.5	300	400	400	900	40	60	30	50	50	70	2.3	4
Ayres gravelly sandy loam, 6 to 12 percent slopes	2.5	4.5	----	350	400	850	35	50	30	50	40	55	2.3	3.8
Ayres sandy loam, 0 to 2 percent slopes	3.5	5	325	400	400	1,000	50	75	40	65	60	80	2.5	4
Ayres sandy loam, 2 to 6 percent slopes	3.5	5	300	400	400	1,000	45	75	35	60	60	80	2.5	4
Ayres sandy loam, 6 to 12 percent slopes	3	5	----	350	400	900	40	60	30	50	50	70	2	4
Ayres stony sandy loam, 0 to 6 percent slopes	2	3	----	----	300	500	40	50	35	45	45	70	2	4
Ayres stony sandy loam, 6 to 20 percent slopes	2	3	----	----	200	400	40	50	35	45	45	65	1.8	3.8
Boyce silty clay loam	----	5.5	----	400	----	1,000	35	60	----	70	----	90	2.5	4
Boyce silt loam	----	6	----	400	400	1,000	40	80	----	65	----	90	2	5
Boyce silt loam, ponded	----	----	----	----	----	----	----	----	----	----	----	----	----	5
Boyce loam, light-colored variant	----	6	----	400	----	1,000	----	80	----	60	----	80	1.5	4.5
Courtrock sandy loam, 0 to 2 percent slopes	4	6	350	500	400	1,100	60	80	40	80	75	95	3.5	5
Courtrock sandy loam, 2 to 6 percent slopes	3.5	5	350	450	400	1,100	55	80	40	80	70	90	3.5	5
Courtrock sandy loam, 6 to 12 percent slopes	----	3.5	----	----	400	800	35	65	35	60	40	75	3	5
Courtrock gravelly sandy loam, 0 to 2 percent slopes	3	4.5	325	400	600	1,000	45	75	35	65	45	80	3	4.3
Courtrock gravelly sandy loam, 2 to 6 percent slopes	2.5	4.5	325	400	600	1,000	40	75	35	65	40	75	3	4
Courtrock gravelly sandy loam, 6 to 12 percent slopes	----	3.5	----	350	400	800	30	60	30	55	40	60	2	3.5
Courtrock stony sandy loam, 2 to 6 percent slopes	1.5	3	----	----	200	600	30	50	30	45	40	50	1.8	2.8
Crooked sandy loam, 0 to 2 percent slopes	2	4	----	350	----	900	25	50	25	60	30	70	1.8	3.5
Crooked sandy loam, 2 to 6 percent slopes	2	4	----	350	----	900	25	50	----	60	----	70	1.5	3.5
Crooked loamy sand, 0 to 2 percent slopes	2	4	----	350	----	800	25	50	25	50	----	70	2.5	3
Crooked loam, 0 to 2 percent slopes	2	4	----	350	----	----	----	60	----	45	----	60	1.5	4
Deschutes sandy loam, 0 to 2 percent slopes	3	5.5	350	450	600	1,000	40	75	35	70	60	80	2	4.5
Deschutes sandy loam, 2 to 6 percent slopes	3	5	350	425	600	1,000	40	75	35	70	55	80	2	4.5
Deschutes sandy loam, 6 to 12 percent slopes	2	4	----	----	----	1,000	30	50	35	70	40	60	2.5	4
Deschutes sandy loam, deep over basalt, 0 to 2 percent slopes	3	5.5	350	450	600	1,000	50	75	45	70	60	90	3	5
Deschutes sandy loam, deep over basalt, 2 to 6 percent slopes	3	5.5	350	400	600	1,000	50	75	50	70	60	85	2.5	5
Deschutes sandy loam, moderately deep over hardpan, 0 to 2 percent slopes	3.5	6	325	450	600	1,000	50	80	45	75	60	90	2	4.5
Deschutes sandy loam, moderately deep over hardpan, 2 to 6 percent slopes	3.5	6	325	450	600	1,100	50	80	45	75	60	90	2	4.5
Deschutes sandy loam, moderately deep over hardpan, 6 to 12 percent slopes	2	4.5	----	400	400	1,000	40	60	35	50	50	60	1	3
Deschutes sandy loam, deep over hardpan, 0 to 2 percent slopes	3.5	6	350	450	600	1,200	50	80	45	75	60	90	2	5.5
Deschutes sandy loam, moderately deep over gravel, 0 to 2 percent slopes	3	5	325	400	600	1,000	45	60	40	65	50	70	2	4.5
Deschutes sandy loam, moderately deep over gravel, 2 to 6 percent slopes	3	5	325	400	600	1,000	40	60	40	65	50	70	2	4
Deschutes stony sandy loam, 0 to 2 percent slopes	2.5	3.5	----	----	400	700	30	50	40	55	40	60	2	4
Deschutes stony sandy loam, 2 to 6 percent slopes	2.5	3.5	----	----	400	700	30	50	30	45	40	50	2	4
Deschutes loamy sand, 0 to 2 percent slopes	3	5	350	425	500	1,000	40	75	35	60	60	80	2	4.5
Deschutes loamy sand, 2 to 6 percent slopes	3	5	350	425	400	1,000	40	70	35	60	55	80	2	4
Deschutes loamy sand, 6 to 20 percent slopes	----	4.5	----	----	200	800	30	60	30	50	30	60	2	4
Deschutes loamy sand, moderately deep over hardpan, 0 to 2 percent slopes	3.5	5.5	350	450	600	1,100	50	80	35	65	60	90	2.5	5
Deschutes loamy sand, moderately deep over hardpan, 2 to 6 percent slopes	3	5.5	350	450	600	1,100	50	80	35	65	60	90	2.5	4.3
Deschutes stony loamy sand, 0 to 6 percent slopes	2.5	3	----	----	400	600	30	50	30	45	40	60	1.5	3.0
Forester loamy sand	1.5	2.5	----	----	----	800	25	55	20	50	20	65	1.3	3.5
Forester sandy loam	2	3	----	----	----	1,000	25	60	25	60	30	75	1.8	4
Lamonta gravelly loam, 6 to 12 percent slopes	----	4	----	----	400	1,000	30	55	30	50	45	80	----	3.8
Lamonta loam, 0 to 6 percent slopes	2	5	----	----	450	1,000	45	70	----	60	----	80	1.8	5
Lookout loam, 0 to 2 percent slopes	3	4.5	----	----	600	1,000	30	55	30	45	45	70	2.5	4.5
Lookout loam, 2 to 6 percent slopes	3	4.5	----	----	600	1,000	30	55	30	45	45	70	2.5	4.5
Metolius sandy loam, 0 to 2 percent slopes	3.5	5	350	400	600	1,000	50	75	40	65	60	95	3	5
Metolius sandy loam, 2 to 6 percent slopes	3.5	5	350	400	600	1,000	50	75	35	60	60	90	3	5
Metolius sandy loam, 6 to 12 percent slopes	2.5	4	----	375	400	1,000	45	65	35	60	45	70	2.5	4.5
Metolius loamy sand, 0 to 2 percent slopes	3.5	5	300	350	500	900	50	75	35	60	50	80	3	4.5
Metolius loamy sand, 2 to 6 percent slopes	3.5	5	300	350	400	900	50	75	35	60	50	80	2.8	4.5
Metolius loamy sand, 6 to 12 percent slopes	3	5	----	350	300	900	45	60	35	55	45	70	2.5	4.5
Metolius loam, 0 to 2 percent slopes	5	6.5	400	500	700	1,200	70	90	50	70	70	110	3.8	6

TABLE 1.—*Estimated average acre yields of principal crops under two levels of management*—Continued

Soil	Alfalfa		Potatoes		Clover for seed		Winter wheat (irrigated)		Spring wheat (irrigated)		Barley (irrigated)		Seeded pasture (irrigated)	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Tons	*Tons*	*Bu.*	*Bu.*	*Lbs.*	*Lbs.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*
Ochoco sandy loam, 0 to 2 percent slopes	3.5	5	325	450	600	1,000	50	75	40	65	60	80	3	5.5
Ochoco sandy loam, seeped, 0 to 2 percent slopes	-----	5	-----	400	600	1,000	30	75	35	50	40	80	2	4.8
Ochoco sandy loam, 2 to 6 percent slopes	3.5	5	325	425	600	1,000	45	75	35	60	60	80	3	5
Ochoco sandy loam, 6 to 12 percent slopes	3	5	-----	350	600	1,000	40	60	30	50	50	70	3	4.5
Ochoco gravelly sandy loam, 0 to 2 percent slopes	3	4.5	300	400	600	1,000	45	60	30	50	50	70	2.8	5
Ochoco gravelly sandy loam, 2 to 6 percent slopes	2.5	4	300	400	600	1,000	45	60	30	50	50	70	2.5	4.5
Ochoco loamy sand, 2 to 6 percent slopes	3	5	325	400	400	900	45	75	40	65	60	80	2.3	4
Ochoco loam, 0 to 2 percent slopes	3.5	5	325	450	600	1,000	50	75	40	65	60	80	3	5.5
Ochoco loam, 2 to 6 percent slopes	3.5	5	325	425	600	1,000	45	75	35	60	60	80	3	5
Ochoco gravelly loam, 2 to 6 percent slopes	3	4.5	300	400	600	1,000	45	70	30	50	60	75	2.5	4.5
Ontko clay loam and clay	-----	4.5	-----	-----	-----	1,100	----	70	----	50	----	70	1.5	5
Polly gravelly loam, 0 to 6 percent slopes	3	4.5	-----	-----	600	1,000	45	60	30	50	50	60	2.5	4.5
Polly gravelly loam, 6 to 12 percent slopes	3	4.5	-----	-----	-----	-----	30	50	30	50	45	50	2.0	3.5
Polly loam, 0 to 6 percent slopes	3	4.5	-----	-----	600	1,000	45	70	35	50	50	70	2.5	4.5
Polly loam, 6 to 12 percent slopes	3	4.5	-----	-----	-----	-----	35	50	30	50	50	60	2.0	3.5
Polly sandy loam, 2 to 6 percent slopes	2	4	275	350	500	1,000	30	60	30	50	35	60	1.8	4
Polly sandy loam, thick surface, 2 to 6 percent slopes	2.5	4.5	300	400	450	1,000	35	60	30	50	50	70	2	4.5
Polly sandy loam, thick surface, 6 to 12 percent slopes	2	4	-----	350	400	1,000	35	50	30	45	40	50	2	4
Powder loam	3	5.5	300	400	600	1,100	50	80	40	60	60	90	2.8	5.5
Powder gravelly loam	3	5	-----	-----	400	800	30	50	35	50	40	70	2	4.5
Powder silt loam	4	6	-----	400	600	1,200	50	80	40	65	60	80	2	5
Powder silt loam, over gravel	4	6	-----	400	500	1,000	45	80	----	----	60	80	2	5
Powder sandy loam	3	5	350	400	600	900	40	70	30	50	55	80	2.5	4.5
Powder fine sandy loam, coarse variant	2	5	-----	400	400	900	30	70	30	50	30	70	1.5	4
Powder fine sandy loam, over gravel, coarse variant	2	4.5	-----	300	400	900	30	50	30	50	30	60	1.5	4
Prineville sandy loam, 0 to 2 percent slopes	3.5	5	350	475	600	1,000	50	70	40	65	60	80	3	5
Prineville sandy loam, 2 to 6 percent slopes	3	5	325	450	600	1,000	45	70	35	60	60	80	3	5
Prineville sandy loam, 6 to 12 percent slopes	2	3.5	-----	400	-----	800	30	60	30	50	45	70	2.5	4
Prineville sandy loam, thick surface, 0 to 2 percent slopes	4	5.5	400	500	700	1,100	50	80	40	65	60	90	3	5
Prineville sandy loam, thick surface, 2 to 6 percent slopes	3.5	5.5	400	500	600	1,100	50	80	40	65	60	90	3	5
Prineville sandy loam, thick surface, 6 to 12 percent slopes	2.5	4.5	-----	450	600	1,000	35	70	30	45	50	80	2.3	4
Prineville gravelly sandy loam, 2 to 6 percent slopes	3	4.5	350	400	450	900	40	65	30	55	50	70	2.5	4
Prineville gravelly sandy loam, 6 to 20 percent slopes	-----	-----	-----	-----	-----	-----	----	----	----	----	----	----	1.5	3
Redmond sandy loam, 0 to 2 percent slopes	3	5.5	350	425	600	1,000	60	80	50	60	70	100	3	5.5
Redmond sandy loam, 2 to 6 percent slopes	3	5	350	400	600	1,100	60	75	50	60	70	95	3	5
Redmond stony sandy loam, 0 to 6 percent slopes	-----	-----	-----	-----	-----	-----	----	----	----	----	----	----	2	4
Redmond loam, 0 to 2 percent slopes	3	5.5	325	425	650	1,100	65	80	50	60	80	100	3.5	5.5
Redmond stony loam, 0 to 6 percent slopes	-----	-----	-----	-----	-----	-----	----	----	----	----	----	----	2	4
Slayton sandy loam, 2 to 20 percent slopes	-----	-----	-----	-----	-----	-----	30	40	30	40	35	45	1	3
Stearns silt loam	-----	3.5	-----	-----	-----	-----	30	65	----	45	----	50	1.3	4
Steiger sandy loam	2	3	-----	-----	-----	-----	30	40	30	40	30	40	2.5	3.5
Swartz silt loam	2	4.5	275	350	500	1,000	35	60	30	45	45	65	2	4.5
Veazie loam	3	5	300	350	600	1,000	50	70	35	55	60	80	3	5
Veazie loam, shallow	2.5	4	-----	-----	500	1,000	40	60	35	50	50	65	2	4
Veazie gravelly loam	2.5	4.5	-----	-----	400	1,000	40	55	35	50	50	60	2	4.8

servation Service, and the county Agricultural Stabilization and Conservation committee.

Yields in columns A are obtained under average, or prevailing, management. Under this management a crop rotation is followed, but other practices are not always adequate. Fertilizer is applied, but generally in amounts less than optimum; fields may be poorly prepared for irrigation; soils may be overirrigated because water is not applied carefully; and soils affected by excess water are not properly drained.

To obtain the yields in columns B, a farmer must:

1. Use suitable crop rotations.
2. Plant crop varieties that are suited to the soil and produce high yields.
3. Apply fertilizer according to needs indicated by soil tests.
4. Level the soil for efficient irrigation.
5. Apply water carefully at the right time and in the amounts needed.

6. Use improved machinery for cultivating, planting, and harvesting.
7. Use suitable practices for improving soils affected by salts and alkali.
8. Provide adequate drainage where needed.

Practices are suggested for groups of soils in the subsection "Management by Capability Units."

Use of Soils in Engineering

Soil surveys are commonly used in engineering work, especially in highway and dam construction and in the hydrological aspects of watershed planning and construction. A knowledge of the physical properties of soils is needed to predict the behavior of soils in engineering as well as in agriculture. Determining the engineering properties of different soil types by laboratory tests can reduce the need for more costly and time-consuming tests at new or proposed sites for engineering structures.

The information in this report can be used to—

1. Make soil and land use studies that will aid in selecting and developing industrial, business, residential, and recreational sites.
2. Make preliminary estimates of the engineering properties of soils that are significant in planning agricultural drainage and irrigation systems, farm ponds, and terraces.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting highway, airport, pipeline, and cable locations.
4. Locate probable sources of gravel and other construction materials.
5. Correlate performance of engineering structures with soils and thus gain information that will be useful in designing and maintaining the structures.
6. Determine the suitability of soil units for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from other published maps and reports and aerial photographs for the purpose of making maps and reports that can be readily used by engineers.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

With the use of the soil map for identification, the engineering interpretations reported here can be useful for many purposes. It should be emphasized that they may not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads and where the excavations are deeper than the depths of layers here reported. Even in those situations, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

This subsection of the report provides engineers with engineering test data for some of the main soils in the Prineville Area and with the estimated physical properties and qualities of untested soils as determined by interpreting soil survey data.

Some terms used by the agricultural soil scientist may be unfamiliar to the engineer, and some terms may have special meaning in soil science. These terms are defined in the Glossary at the end of this report.

Engineering classification systems

Two systems are used to classify soils according to their engineering properties, that of the American Association of State Highway Officials, the AASHO system (*1*), and that developed by the Corps of Engineers, U.S. Army, the Unified system (*17*).

In the AASHO system, the soils are grouped according to their load-bearing capacity and service into seven basic groups, designated A–1 through A–7. The best soils for road subgrades are classified as A–1, and the poorest as A–7. Within each group the relative engineering value of the soil material can be indicated by a group index number. Group index numbers range from 0 for the best materials to 20 for the poorest. The group index number is shown in parentheses following the soil group symbol; for example, A–4(1). It is given for the soil samples on which engineering tests were made (see table 2, p. 26).

In the Unified classification, the soils are grouped on the basis of their texture and plasticity. This system is less detailed than the AASHO system, but the two are enough alike so that a soil classified according to one can be readily classified according to the other. The Unified system recognizes eight classes of coarse-grained soils, six classes of fine-grained soils, and highly organic soils. Coarse-grained soils are those that have 50 percent or less of material passing the No. 200 sieve; fine-grained soils are those that have more than 50 percent of material passing the No. 200 sieve. Coarse-grained material is identified as gravel (G) or sand (S), the two of which are placed in eight secondary groups—GW, GP, GM, GC, SW, SP, SM, and SC. These secondary groups are based on the amount and kind of fines and the shape of the grain-size distribution curve.

Depending on their liquid limit and plasticity index, fine-grained soils are divided into silts (M) and clays (C). Each of these is divided into two secondary groups —MH or CH if the liquid limit is greater than 50, and ML or CL if it is less than 50. Also recognized in the Unified system are organic silts (OL), organic clays (OH), and peat or other highly organic soils (Pt).

Engineering test data

Table 2 gives engineering test data for soil samples taken from seven soil profiles in the survey area. The tests were performed by the Bureau of Public Roads in accordance with standard AASHO procedures. Results of mechanical analyses made by this method frequently differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material, or that passing the No. 200 sieve, is analyzed by the hydrometer method, and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters but not larger than 3 inches in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method, and the material coarser than 2 millimeters in diameter is excluded

TABLE 2.—*Engineering test data* [1] *for*

[Tests performed by Bureau of Public Roads (BPR) in accordance with standard

Soil name and location	Parent material	BPR report number	Depth	Horizon	Moisture-density		Mechanical analysis [2]			
					Maximum dry density	Optimum moisture	Estimated percentage larger than 3 inches discarded in field sampling	Percentage passing sieve [3]—		
								3-in.	2-in.	1½-in.
		S-80	*Inches*		*Lb. per cu. ft.*	*Percent*				
Ayres gravelly sandy loam: SE¼SE¼SE¼ sec. 19, T. 15 S., R. 15 E.	Colluvium.	267	0–8	A1 and A3	100	19	------	------	100	96
		268	8–14	B2t	95	23	10	90	90	71
Day clay: SE¼NE¼NE¼ sec. 7, T. 14 S., R. 16 E.	Clays of John Day formation.	271	0–3	A1	81	32	------	------	------	------
		272	3–31	AC and C1	83	28	------	------	------	------
		273	31–96	C2ca and C3.	81	37	------	------	------	------
Deschutes loamy sand: SE¼NE¼NE¼ sec. 19, T. 16 S., R. 14 E.	Dacite pumice over basalt.	274	0–10	A1 and A3	95	20	------	------	------	------
		275	10–17	B2	93	21	------	------	------	------
		276	17–30	Cca and IIR.	108	16	------	------	------	------
Deschutes sandy loam (deep phase): NE¼NW¼NE¼ sec. 2, T. 16 S., R. 14 E.	Dacite pumice over alluvium.	277	0–24	Ap, A3, and B2.	95	21	------	------	------	------
		278	24–50	IICca	116	14	50	50	44	33
Lamonta gravelly loam: NW¼NE¼SW¼ sec. 32, T. 13 S., R. 15 E.	Alluvium in fans.	285	0–9	Ap and Blt.	104	18	------	------	------	100
		286	9–20	B21t and B22t.	77	40	10	90	90	90
Searles stony clay loam: NW¼NW¼NW¼ sec. 32, T. 14 S., R. 15 E.	Clarno tuff.	279	0–7	A1 and A3	87	27	30	70	------	70
		280	7–14	B2t	81	36	------	------	------	100
		281	14–36	B3ca and Cca.	72	44	------	------	------	------
Swartz silt loam: SE¼SW¼SE¼ sec. 34, T. 14 S., R. 15 E.	Alluvium.	287	0–5	A1 and A2	101	20	------	------	------	------
		288	5–32	B21t, B22t, and B3.	79	35	------	------	------	------
		289	32–45	C1	83	32	------	------	------	------

[1] Based on AASHO Designation: T 99–57, Method A (*1*).

[2] Mechanical analysis according to AASHO Designation: T 88–57(*1*). Results by this procedure may differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method, and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method, and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analysis data used in this table are not suitable for naming textural classes for soils.

from calculations of grain-size fractions. A comparison of these and other systems of size limits for soil separates can be found in the PCA Soil Primer (*6*). Table 2 shows both the AASHO and the Unified classifications.

Estimated physical properties of untested soils

Table 3 gives the estimated physical properties and qualities of untested soils, as determined by interpreting soil survey data. The estimates for liquid limit and plasticity index were based largely on clay content. The estimates were checked with the estimates for optimum moisture and maximum dry density, which also are closely related to the amounts of various particle sizes.

Descriptions of Soils

This section describes the soil series (groups of soils) and single soils (mapping units) of the Prineville Area. The acreage and proportionate extent of each mapping unit are given in table 4.

The procedure in this section is to describe first the soil series and then the mapping units in that series.

soil samples taken from seven soil profiles

procedures of the American Association of State Highway Officials (AASHO) (*1*)]

Mechanical analysis [2]—Continued												Liquid limit	Plasticity index	Classification	
Percentage passing sieve [3]—Continued								Percentage smaller than [3]—							
1-in.	¾-in.	⅜-in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.			AASHO [4]	Unified [5]
94	90	86	84	83	74	62	39	33	25	17	12	29	2	A-4(1)	SM.
68	65	64	63	62	58	53	42	40	32	26	20	37	13	A-6(1)	GM-GC.
------	------	------	100	99	97	95	90	88	80	71	66	76	32	A-7-5(20)	MH.
------	------	------	100	99	96	95	90	88	77	66	60	74	37	A-7-5(20)	MH.
------	------	------	------	100	99	96	90	79	66	57	51	97	51	A-7-5(20)	MH.
100	99	98	98	98	85	69	43	34	23	15	11	(6)	(6)	A-4(2)	SM.
------	100	99	99	99	83	63	34	27	17	10	8	(6)	(6)	A-2-4(0)	SM.
100	98	97	96	94	85	79	56	42	24	11	7	(6)	(6)	A-4(4)	ML.
100	98	95	93	91	79	64	37	28	20	12	8	(6)	(6)	A-4(0)	SM.
32	26	21	17	13	8	7	5	4	3	2	1	(6)	(6)	A-1-a(0)	GW-GM.
98	96	92	88	84	77	71	54	45	32	19	14	30	6	A-4(4)	ML-CL.
88	87	86	85	76	74	71	64	61	57	51	49	94	48	A-7-5(20)	MH.
69	68	66	62	57	52	50	43	40	34	28	24	60	30	A-7-5(16)	MH-CH.
99	97	95	92	83	75	72	66	64	58	51	46	90	49	A-7-5(17)	MH.
------	------	100	96	87	86	85	82	80	74	65	57	104	57	A-7-5(20)	MH.
------	------	------	------	100	99	97	88	81	56	32	21	28	6	A-4(8)	ML-CL.
------	------	------	------	100	99	98	95	93	84	73	63	68	28	A-7-5(19)	MH.
------	------	------	------	100	99	98	97	95	87	72	60	64	30	A-7-5(20)	MH.

Thus, to get full information on any one mapping unit, it is necessary to read the description of that unit and also the description of the soil series to which it belongs. As mentioned in the section "How Soils Are Mapped and Classified," not all mapping units are members of a soil series. Rock land, for example, does not belong to a soil series but, nevertheless, is listed in alphabetical order along with the soil series.

Following the name of each mapping unit, there is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of the description of most mapping units is the capability unit in which the mapping unit has been placed. In a number of soil complexes and groups of undifferentiated soils, however, the individual soils that make up the complex or the undifferentiated group have been placed in different capability units. For these mapping units, two or more capability units are listed. The page on which each capability unit is described can be readily found by referring to the "Guide to Mapping Units" at the back of the report.

Soil scientists, engineers, students, and others who want further information about the soil series should turn to the section "Formation, Classification, and Morphology of Soils." Many terms used in the soil descriptions and in other sections of the report are defined in the Glossary.

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[3] Based on the total amount of material. Laboratory test data corrected for the amount discarded in field sampling.

[4] Based on Standard Specifications for Highway Materials and Methods of Sampling and Testing (Pt. 1, Ed. 7): The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes, AASHO Designation: M 145-49.

[5] Based on the Unified Soil Classification System, Technical Memorandum No. 3-357, Vol. 1, Waterways Experiment Station, Corps of Engineers, March 1953 (*17*). SCS and BPR have agreed to consider that all soils having plasticity indexes within two points of A-line are to be given a borderline classification. Examples of borderline classifications obtained by this use are GM-GC, ML-CL, and MH-CH.

[6] Nonplastic.

TABLE 3.—*Estimated physical properties and qualities of untested*

Soil series	Drainage	Depth from surface	Horizon	Classification		Grain size	
				Unified	AASHO	Percentage passing sieve—	
						No. 200 (0.074 mm.)	No. 4 (4.7 mm.)
		Inches					
Agency (AaE, AaG)	Good.	0–11	A1, A3	SM	A–1 or A–2	15	60
		11–22	B1t, B2t	SC	A–4	40	65
		22–36	C1ca	SM–SC or GM–GC.	A–2	25	60
Bakeoven (BaD, BbD; and in complexes DuB and DvB).	Good.	0–4	A1	GM–GC	A–2	25	35
		4–12	B1t, B2t	GM–GC	A–2	30	40
Boyce (Br, Bs, Bw, By)	Poor or very poor.	0–3	A11	OH	A–7	85	100
		3–24	A12g, A13g, AC1g, AC2.	MH	A–7	80	100
		24–31	C	CL	A–6	55	100
Courtrock (CkA, CkB, CkC, CmA, CmB, CmC, CoB, CoD).	Good.	0–16	Ap, B1	SM	A–4	40	98
		16–30	B21, B22	SM–SC	A–4	40	85
		30–60	C1ca, C2ca, C3ca.	SM	A–1	25	80
Crooked (CrA, CsA, CtA, CtB; and in complex Sm).	Imperfect.	0–13	Ap, AC	SM	A–4	55	100
		13–33	Cm, C2m	(²)	(²)	(²)	(²)
		33–60	C3	ML–CL	A–4	60	100
Elmore (EmE)	Good.	0–14	A1, A3, B1t	ML	A–2	35	50
		14–35	B21t, B22t	ML	A–2	25	30
		35–50	B23t	GP–GC	A–2	7	10
Forester (Fo, Fr)	Imperfect.	0–12	Ap, AC	SM	A–4	45	100
		12–27	C1, C2	SM	A–4	40	100
		27–48	IIC3	ML–CL	A–4	55	100
Gem (GaD, GbE; also in complexes GcE and GgE).	Good.	0–13	A1, A3, B1t	ML	A–2	35	55
		13–28	B2t, B3tca	GM	A–2	30	55
Lookout (LoA, LoB, LsB, LsD, LvE).	Good.	0–8	A1	ML	A–4	45	70
		8–20	B1t, B2t, B3tca.	MH	A–7	50	70
		20–30	Csim	(³)	(³)	(³)	(³)
Metolius (MaA, MoA, MoB, MoC, MsA, MsB, MsC, MsD).	Good or somewhat excessive.	0–18	Ap, C1	SM	A–2	35	95
		18–60	C2, C3	SM	A–2	35	95
Ochoco (OcA, OcB, OdB, OgB, OhA, OhB, OmA, OmB, OmC, OoA; and in soil groups AoA, AoB, AoC, AoD, ArA, ArD, ArE, AsB).	Good.	0–21	Ap, A3, B1t	SM	A–4	40	95
		21–36	B2t, B3	SC	A–4	40	90
		36–46	C1simca	(²)	(²)	(²)	(²)

soils in the Area as determined by interpreting soil survey data

Liquid limit	Plasticity index	Permeability	Structure	pH	Alkali	Shrink-swell potential	Other characteristics of series
		In. per hr.					
(1)	(1)	5.0–10.0	Weak, very fine, granular	6.8–7.0	None	Low.	Very stony, 25 to 50 percent of stones larger than 3 inches; steep slopes.
30	10	0.2–0.8	Moderate, medium and fine, blocky.	7.3–8.0	None	Moderate.	
25	5	0.2–10.0	Massive	8.0–8.4	None	Low.	
30	5	0.8–2.5	Moderate, thin, platy and weak, fine, granular.	6.6–6.8	None	Moderate.	Very stony, 40 to 60 percent of stones larger than 3 inches.
41	12	0.2–0.8	Moderate, fine and medium, blocky.	6.8–7.0	None	Moderate to high.	
70	30	0.8–2.5	Moderate, medium, granular	7.5–8.4	Slight to strong.	Moderate.	Fluctuating high water table.
65	30	0.2–0.8	Moderate, medium and fine, blocky.	8.0–8.4	Slight to strong.	Moderate.	
35	12	0.2–10.0	Massive	7.6–8.4	Slight to strong.	Moderate.	
(1)	(1)	5.0–10.0	Weak, fine, granular	6.8–7.0	None	Low.	Below depth of 16 inches, 10 to 15 percent of cobbles larger than 3 inches; lime below depth of about 30 inches.
32	5	0.8–2.5	Weak, medium, subangular blocky and blocky.	7.0–7.8	None	Low.	
28	2	5.0–10.0	Massive	7.9–8.4	None	Low.	
(1)	(1)	0.8–2.5	Weak, fine, granular	8.5–9.8	Moderate to strong.	Low.	Fluctuating high water table.
(2)	(2)	<0.2	(2)	8.0–10.0	Moderate to strong.	None.	
20	5	0.8–2.5	Massive, stratified	8.5–9.6	Moderate to strong.	Low.	
30	5	0.8–2.5	Weak, platy and weak, fine, granular.	6.3–7.0	None	Low.	Very stony, 35 to 50 percent of stones larger than 3 inches.
65	35	0.2–0.8	Moderate, medium, prismatic and medium and fine, blocky.	7.0–7.3	None	Low.	
60	30	0.2–0.8	Weak, medium and fine, blocky	7.4–7.6	None	Low.	
(1)	(1)	5.0–10.0	Weak, platy to single grain	9.0–9.6	Slight to strong.	Low.	
(1)	(1)	5.0–10.0	Massive	8.6–9.6	Slight to strong.	Low.	
30	5	0.8–2.5	Massive to weak, platy	8.5–9.0	Slight to strong.	Low.	
35	8	0.8–2.5	Moderate, granular and blocky	6.5–7.0	None	Low.	Stony or very stony, about 35 percent of stones larger than 3 inches.
75	38	0.2–0.8	Moderate, prismatic and strong, fine, blocky.	7.0–8.2	None	Moderate.	
35	10	0.8–2.5	Moderate, platy and granular	6.7–6.8	None	Low.	Nonstony to very stony, 15 to 25 percent of cobbles larger than 3 inches.
78	40	0.05–0.2	Strong, prismatic and blocky	6.8–8.0	None	High.	
(3)	(3)	0.05	(3)	8.3	None	None.	
(1)	(1)	5.0–10.0	Weak, platy, massive, granular or single grain.	6.8–7.3	None	Low.	
(1)	(1)	5.0–10.0	Massive to single grain	7.3–8.2	None	Low.	
(1)	(1)	0.8–10.0	Weak, granular and subangular blocky.	6.8–7.3	None	Low.	
30	10	0.2–2.5	Weak, prismatic and moderate, fine, subangular blocky.	7.2–7.8	None	Moderate.	
(2)	(2)	<2.5	(2)	7.8–8.4	None	None.	

TABLE 3.—*Estimated physical properties and qualities of untested soils*

Soil series	Drainage	Depth from surface	Horizon	Classification		Grain size	
				Unified	AASHO	Percentage passing sieve—	
						No. 200 (0.074 mm.)	No. 4 (4.7 mm.)
		Inches					
Ontko (Op, Ot)	Poor or very poor.	0–7	Ap	MH	A–7	85	100
		7–22	A1, AC	MH	A–7	80	100
		22–43+	C1, C2	ML–CL	A–4	55	90
Polly (PaB, PaC, PgB, PgC, PhB, PkB, PkC, PlD).	Good.	0–6	A1	ML–CL	A–4	50	80
		6–18	B1t, B2t	MH	A–7	60	80
		18–72	B3, C1ca, C2	CH	A–7	60	85
Powder (Pm, Pn, Po, Pr, Ps, Pt, Pu).	Good or moderately good.	0–13	Ap, AC	ML–CL	A–4	70	100
		13–48	C1, C2, C3, C4	ML–CL	A–4	70	100
		48–80	C5	ML–CL	A–4	60	100
Prineville (PvA, PvB, PvC, PwA, PwB, PwC, PxB, PxD).	Good.	0–20	Ap, A3, B2	SM	A–4	40	95
		20–47	C1m, C2m	SM	A–4	45	95
		47–60	C3	SM	A–2	30	85
Redmond (RdA, RmA, RmB, RnB, RoB, RrC).	Good.	0–15	A1, A3, B1t	SM	A–4	40	95
		15–34	B2t, C1, C2ca	CL–ML	A–4	55	95
Salisbury (SaB, SbB, SbD)	Good.	0–8	A1, A3	SM	A–4	36	60
		8–21	B1t, B2t	MH	A–7	45	65
		21–38	C1m, C2m	(3)	(3)	(3)	(3)
Slayton (ShD, ShE, SkD; also in complexes SfD and SfE).	Good.	0–8	A1, AC	SM	A–2	25	65
		8–14	C	SM–SC	A–2	26	60
Stearns (Sl; and in complex Sm).	Imperfect.	0–5	A21, A22	ML–MH	A–7	85	100
		5–13	B2t	MH	A–7	92	100
		13–36	C1ca, C2ca	MH	A–7	80	100
Steiger (Ss)	Good.	0–14	Ap, AC	SM	A–4	45	100
		14–28	C1, C2	SM–SC	A–4	48	100
		28–69	C3	SM	A–4	40	100
Veazie (Va, Vb, Vg; and in complex Vr).	Good or somewhat excessive.	0–16	A1, AC	ML–CL	A–4	55	95
		16–24	C1	ML–CL	A–4	50	90
		24+	IIC2	GM	A–1	10	40

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[1] NP=nonplastic.

[2] Weakly to strongly cemented hardpan.

in the Area as determined by interpreting soil survey data—Continued

Liquid limit	Plasticity index	Permeability	Structure	pH	Alkali	Shrink-swell potential	Other characteristics of series
		In. per hr.					
65	30	0. 2–2. 5	Moderate, fine, granular	6. 6–7. 0	None	Moderate to high.	
55	25	0. 05–0. 8	Weak or moderate, fine, subangular blocky.	6. 7–7. 2	None	Moderate to high.	
25	5	0. 2–5. 0	Massive	6. 2–7. 6	None	Low to moderate.	
30	5	0. 8–2. 0	Moderate, fine, granular	6. 7–7. 0	None	Low.	0 to 35 percent stones and gravel in upper 2 feet.
80	40	0. 2–0. 8	Weak or moderate, prismatic and moderate or strong, fine, blocky.	6. 8–7. 8	None	Moderate to high.	
65	35	0. 2–2. 5	Moderate, blocky to massive	7. 6–8. 4	None	Low to moderate.	
30	5	0. 8–10. 0	Weak, granular	8. 0–8. 3	None	Low.	
30	5	0. 8–5. 0	Weak, subangular blocky to massive.	8. 0–8. 3	None	Low.	
25	4	0. 8–10. 0	Massive	8. 2	None	Low.	
(1)	(1)	2. 5–10. 0	Weak, fine, granular to weak, subangular blocky.	6. 8–8. 2	None	Low.	
(1)	(1)	0. 8–2. 5	Platy, weakly to strongly cemented hardpan lenses.	8. 2–9. 2	None	Low.	
(1)	(1)	>10. 0	Massive	8. 3–9. 0	None	Low.	
(1)	(1)	0. 8–10. 0	Weak, fine, granular	6. 7–7. 0	Normally none.	Low.	
30	7	0. 8–2. 5	Weak, medium and fine, blocky to massive.	7. 2–8. 2	Normally none.	Low to moderate.	
35	7	0. 8–2. 5	Moderate, granular and subangular blocky.	6. 6–7. 0	None	Low.	30 percent of cobbles are larger than 3 inches.
80	38	0. 05–0. 2	Prismatic and strong, fine, blocky.	6. 7–7. 5	None	High.	
(3)	(3)	<0. 2	(3)	7. 0–8. 4	None	None.	
(1)	(1)	5. 0–10. 0	Weak, fine, granular and subangular blocky.	6. 6–6. 8	None	Low.	20 to 50 percent of channery fragments larger than 3 inches.
20	5	5. 0–10. 0	Weak, subangular blocky	7. 0–7. 2	None	Low.	
50	20	0. 8–2. 5	Moderate, platy	6. 8–9. 0	Moderate to strong.	Low.	
65	30	0. 05–0. 2	Moderate to strong, prismatic and blocky.	9. 0–10. 0	Moderate to strong.	Moderate.	
55	20	0. 05–0. 8	Weakly lime-cemented pan	9. 2–10. 0	Moderate to strong.	Low.	
25	2	0. 8–10. 0	Weak, fine, granular	6. 6–6. 8	None	Low.	
28	4	5. 0–10. 0	Weak, subangular blocky	6. 9–7. 6	None	Low.	
(1)	(1)	2. 5–10. 0	Massive	7. 5	None	Low.	
30	5	0. 8–2. 5	Weak, granular and subangular blocky.	6. 6–7. 0	None	Low.	35 percent of pebbles larger than 3 inches.
30	5	0. 8–2. 5	Massive, stratified	6. 6–7. 0	None	Low.	
(1)	(1)	>10. 0	Massive, stratified	6. 6–7. 0	None	Low.	

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[3] Strongly cemented hardpan.

TABLE 4.—*Approximate acreage and proportionate extent of the soils*

Map symbol	Soil	Area	Extent
		Acres	*Percent*
AaE	Agency very stony sandy loam, 6 to 40 percent slopes	4,898	2.9
AaG	Agency very stony sandy loam, 40 to 70 percent slopes	648	.4
AdB	Ayres sandy loam, 2 to 6 percent slopes	1,608	1.0
AdC	Ayres sandy loam, 6 to 12 percent slopes	224	.1
AgB	Ayres gravelly sandy loam, 2 to 6 percent slopes	2,678	1.6
AgC	Ayres gravelly sandy loam, 6 to 12 percent slopes	726	.4
AmB	Ayres stony sandy loam, 0 to 6 percent slopes	2,483	1.5
AmD	Ayres stony sandy loam, 6 to 20 percent slopes	1,740	1.0
AoA	Ayres and Ochoco sandy loams, 0 to 2 percent slopes	3,886	2.3
AoB	Ayres and Ochoco sandy loams, 2 to 6 percent slopes	1,081	.6
AoC	Ayres and Ochoco sandy loams, 6 to 12 percent slopes	385	.2
AoD	Ayres and Ochoco sandy loams, 12 to 20 percent slopes	180	.1
ArA	Ayres and Ochoco gravelly sandy loams, 0 to 2 percent slopes	1,555	.9
ArD	Ayres and Ochoco gravelly sandy loams, 6 to 20 percent slopes	1,102	.7
ArE	Ayres and Ochoco gravelly sandy loams, 20 to 40 percent slopes	371	.2
AsB	Ayres and Ochoco stony sandy loams, 0 to 6 percent slopes	3,198	1.9
BaD	Bakeoven very stony loam, 0 to 20 percent slopes	7,402	4.4
BbD	Bakeoven very stony sandy loam, 0 to 20 percent slopes	7,821	4.6
Bp	Borrow pits	98	(1)
Br	Boyce loam, light-colored variant	570	.3
Bs	Boyce silt loam	1,341	.8
Bw	Boyce silt loam, ponded	357	.2
By	Boyce silty clay loam	820	.5
CkA	Courtrock sandy loam, 0 to 2 percent slopes	327	.2
CkB	Courtrock sandy loam, 2 to 6 percent slopes	443	.3
CkC	Courtrock sandy loam, 6 to 12 percent slopes	372	.2
CmA	Courtrock gravelly sandy loam, 0 to 2 percent slopes	423	.3
CmB	Courtrock gravelly sandy loam, 2 to 6 percent slopes	257	.2
CmC	Courtrock gravelly sandy loam, 6 to 12 percent slopes	309	.2
CoB	Courtrock stony sandy loam, 2 to 6 percent slopes	183	.1
CoD	Courtrock stony sandy loam, 6 to 20 percent slopes	345	.2
CrA	Crooked loam, 0 to 2 percent slopes	584	.3
CsA	Crooked loamy sand, 0 to 2 percent slopes	280	.2
CtA	Crooked sandy loam, 0 to 2 percent slopes	1,361	.8
CtB	Crooked sandy loam, 2 to 6 percent slopes	186	.1
DaE	Day clay, 6 to 40 percent slopes	142	(1)
DcA	Deschutes loamy sand, 0 to 2 percent slopes	1,042	.6
DcB	Deschutes loamy sand, 2 to 6 percent slopes	1,533	.9
DcD	Deschutes loamy sand, 6 to 20 percent slopes	341	.2
DdA	Deschutes loamy sand, moderately deep over hardpan, 0 to 2 percent slopes	471	0.3
DdB	Deschutes loamy sand, moderately deep over hardpan, 2 to 6 percent slopes	340	.2
DmB	Deschutes stony loamy sand, 0 to 6 percent slopes	1,164	.7
DnA	Deschutes sandy loam, 0 to 2 percent slopes	5,923	3.5
DnB	Deschutes sandy loam, 2 to 6 percent slopes	4,693	2.8
DnC	Deschutes sandy loam, 6 to 12 percent slopes	426	.3
DoA	Deschutes sandy loam, moderately deep over hardpan, 0 to 2 percent slopes	3,362	2.0
DoB	Deschutes sandy loam, moderately deep over hardpan, 2 to 6 percent slopes	1,421	.8
DoC	Deschutes sandy loam, moderately deep over hardpan, 6 to 12 percent slopes	174	.1
DpA	Deschutes sandy loam, deep over hardpan, 0 to 2 percent slopes	199	.1
DrA	Deschutes sandy loam, moderately deep over gravel, 0 to 2 percent slopes	295	.2
DrB	Deschutes sandy loam, moderately deep over gravel, 2 to 6 percent slopes	442	.3
DsA	Deschutes sandy loam, deep over basalt, 0 to 2 percent slopes	419	.2
DsB	Deschutes sandy loam, deep over basalt, 2 to 6 percent slopes	279	.2
DtA	Deschutes stony sandy loam, 0 to 2 percent slopes	2,194	1.3
DtB	Deschutes stony sandy loam, 2 to 6 percent slopes	5,002	3.0
DtD	Deschutes stony sandy loam, 6 to 20 percent slopes	434	.3
DuB	Deschutes-Bakeoven very stony sandy loams, 0 to 6 percent slopes	153	(1)
DvB	Deschutes-Bakeoven sandy loams, 0 to 6 percent slopes	1,722	1.0
EmE	Elmore very stony loam, 6 to 40 percent slopes	1,470	.9
Fo	Forester loamy sand	208	.1
Fr	Forester sandy loam	434	.3
GaD	Gem stony loam, 6 to 20 percent slopes	287	.2
GbE	Gem very stony loam, 6 to 40 percent slopes	2,508	1.5
GcE	Gem-Day stony clay loams, 12 to 40 percent slopes	967	.6
GgE	Gem-Searles stony loams, 6 to 40 percent slopes	2,515	1.5
LaB	Lamonta loam, 0 to 6 percent slopes	80	(1)
LgC	Lamonta gravelly loam, 6 to 12 percent slopes	189	.1
LmD	Lamonta stony loam, 6 to 20 percent slopes	181	.1
LoA	Lookout loam, 0 to 2 percent slopes	341	.2
LoB	Lookout loam, 2 to 6 percent slopes	308	.2
LsB	Lookout stony loam, 0 to 6 percent slopes	420	.2
LsD	Lookout stony loam, 6 to 20 percent slopes	578	.3
LvE	Lookout very stony loam, 0 to 40 percent slopes	3,655	2.2
MaA	Metolius loam, 0 to 2 percent slopes	625	.4

TABLE 4.—*Approximate acreage and proportionate extent of the soils*—Continued

Map symbol	Soil	Area	Extent
		Acres	*Percent*
MoA	Metolius loamy sand, 0 to 2 percent slopes	224	0.1
MoB	Metolius loamy sand, 2 to 6 percent slopes	546	.3
MoC	Metolius loamy sand, 6 to 12 percent slopes	291	.2
MsA	Metolius sandy loam, 0 to 2 percent slopes	1,240	.7
MsB	Metolius sandy loam, 2 to 6 percent slopes	667	.4
MsC	Metolius sandy loam, 6 to 12 percent slopes	107	(1)
MsD	Metolius sandy loam, 12 to 20 percent slopes	311	.2
OcA	Ochoco loam, 0 to 2 percent slopes	329	.2
OcB	Ochoco loam, 2 to 6 percent slopes	141	(1)
OdB	Ochoco loamy sand, 2 to 6 percent slopes	239	.1
OgB	Ochoco gravelly loam, 2 to 6 percent slopes	249	.1
OhA	Ochoco gravelly sandy loam, 0 to 2 percent slopes	416	.2
OhB	Ochoco gravelly sandy loam, 2 to 6 percent slopes	900	.5
OmA	Ochoco sandy loam, 0 to 2 percent slopes	3,315	2.0
OmB	Ochoco sandy loam, 2 to 6 percent slopes	1,328	.8
OmC	Ochoco sandy loam, 6 to 12 percent slopes	214	.1
OoA	Ochoco sandy loam, seeped, 0 to 2 percent slopes	116	(1)
Op	Ontko clay loam, ponded	235	.1
Ot	Ontko clay loam and clay	627	.4
PaB	Polly loam, 0 to 6 percent slopes	584	.3
PaC	Polly loam, 6 to 12 percent slopes	556	.3
PgB	Polly gravelly loam, 0 to 6 percent slopes	329	.2
PgC	Polly gravelly loam, 6 to 12 percent slopes	503	.3
PhB	Polly sandy loam, 2 to 6 percent slopes	144	(1)
PkB	Polly sandy loam, thick surface, 2 to 6 percent slopes	171	.1
PkC	Polly sandy loam, thick surface, 6 to 12 percent slopes	245	.1
PlD	Polly stony loam, 6 to 20 percent slopes	399	.2
Pm	Powder loam	1,293	.8
Pn	Powder fine sandy loam, coarse variant	330	.2
Po	Powder fine sandy loam, over gravel, coarse variant	152	(1)
Pr	Powder gravelly loam	194	.1
Ps	Powder sandy loam	705	.4
Pt	Powder silt loam	2,167	1.3
Pu	Powder silt loam, over gravel	420	.2
PvA	Prineville sandy loam, 0 to 2 percent slopes	2,409	1.4
PvB	Prineville sandy loam, 2 to 6 percent slopes	2,110	1.3
PvC	Prineville sandy loam, 6 to 12 percent slopes	908	0.5
PwA	Prineville sandy loam, thick surface, 0 to 2 percent slopes	257	.2
PwB	Prineville sandy loam, thick surface, 2 to 6 percent slopes	500	.3
PwC	Prineville sandy loam, thick surface, 6 to 12 percent slopes	255	.2
PxB	Prineville gravelly sandy loam, 2 to 6 percent slopes	121	(1)
PxD	Prineville gravelly sandy loam, 6 to 20 percent slopes	307	.2
RdA	Redmond loam, 0 to 2 percent slopes	3,957	2.4
RmA	Redmond sandy loam, 0 to 2 percent slopes	5,500	3.3
RmB	Redmond sandy loam, 2 to 6 percent slopes	628	.4
RnB	Redmond stony loam, 0 to 6 percent slopes	450	.3
RoB	Redmond stony sandy loam, 0 to 6 percent slopes	2,870	1.7
RrC	Redmond very stony sandy loam, 6 to 12 percent slopes	678	.4
Rv	Riverwash	988	.6
Rx	Rock land	12,775	7.6
Ry	Rock outcrop	1,285	.8
SaB	Salisbury loam, 0 to 6 percent slopes	155	(1)
SbB	Salisbury very stony loam, 0 to 6 percent slopes	1,109	.7
SbD	Salisbury very stony loam, 6 to 20 percent slopes	728	.4
ScD	Searles stony loam, 2 to 20 percent slopes	1,394	.8
ScE	Searles stony loam, 20 to 40 percent slopes	3,390	2.0
SdD	Searles stony clay loam, 6 to 20 percent slopes	166	(1)
SdE3	Searles stony clay loam, 20 to 40 percent slopes, severely eroded	138	(1)
SeD	Searles stony sandy loam, 6 to 20 percent slopes	766	.5
SeE	Searles stony sandy loam, 20 to 40 percent slopes	801	.5
SfD	Searles-Slayton complex, 2 to 20 percent slopes	428	.3
SfE	Searles-Slayton complex, 20 to 40 percent slopes	519	.3
ShD	Slayton channery sandy loam, 2 to 20 percent slopes	481	.3
ShE	Slayton channery sandy loam, 20 to 40 percent slopes	415	.2
SkD	Slayton sandy loam, 2 to 20 percent slopes	1,241	.7
Sl	Stearns silt loam	1,200	.7
Sm	Stearns-Crooked complex	296	.2
Ss	Steiger sandy loam	232	.1
Sw	Swartz silt loam	478	.3
Va	Veazie loam	487	.3
Vb	Veazie loam, shallow	212	.1
Vg	Veazie gravelly loam	620	.4
Vr	Veazie-Riverwash complex	407	.2
	Total	168,528	100.0

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(1) Less than 0.1 percent.

Agency Series

Soils of the Agency series are rolling to very steep, light colored, very stony, and well drained. These soils occur between the bottom land of the Crooked River and the basalt rimrock of the upland plateau. They developed from mixed volcanic and water-deposited materials that were derived from pumice, sandstone, gravel, and basalt. The plant cover consists mainly of sagebrush, bluebunch wheatgrass, Sandberg bluegrass, and scattered juniper.

These soils have surface and subsurface layers of light brownish-gray, neutral very stony sandy loam. The surface layer combined with the subsurface layer is about 11 inches thick. The subsoil, to a depth of about 22 inches, is brown very stony clay loam. Depth to bedrock ranges from 18 to 40 inches and varies widely within short distances.

Agency soils are used entirely for grazing.

Agency very stony sandy loam, 6 to 40 percent slopes (AaE).—This sloping to steep soil occurs mainly in a nearly continuous area between the bottom land of the Crooked River and the basalt rimrock of the upland plateau. The area is 1/16 to 1/4 mile wide and more than 10 miles long.

Representative profile:

0 to 11 inches, light brownish-gray very stony sandy loam; neutral.
11 to 22 inches, brown very stony clay loam; mildly to moderately alkaline; calcareous in lower part.
22 to 36 inches, light brownish-gray very gravelly and stony sandy loam or sandy clay loam; moderately alkaline; calcareous.
36 inches +, light brownish-gray gravel and stones grading to sandstone or basalt.

This soil is very stony or extremely stony. On Grass and Coyote Buttes, it is underlain by cinders. Included in some areas mapped as this soil are areas of Agency very stony sandy loam, 40 to 70 percent slopes, that make up 10 to 15 percent of the acreage mapped. Also included are small areas of Rock outcrop and Deschutes stony sandy loam, 6 to 20 percent slopes.

Runoff is slow to medium, and water erosion is a moderate hazard. Permeability is moderately slow in the subsoil. Fertility and the moisture-holding capacity are low. Roots penetrate to a moderate depth.

This soil is used for limited grazing in spring and fall. It is not suitable for irrigation. *Capability unit VIIs-1*

Agency very stony sandy loam, 40 to 70 percent slopes (AaG).—In many places this very steep soil is shallower and more stony than Agency very stony sandy loam, 6 to 40 percent slopes. On north-facing slopes the surface layer is grayish brown and is covered by a stand of bluebunch wheatgrass that is denser than that on south-facing slopes, where the surface layer is light brownish gray.

Included in some areas mapped as this soil are areas of Agency very stony sandy loam, 6 to 40 percent slopes, and areas of Rock land and Rock outcrop that make up as much as 15 percent of the acreage mapped.

This soil has rapid or very rapid runoff and is highly susceptible to water erosion. It is not suitable for irrigation but is used for limited grazing, mainly by sheep. *Capability unit VIIs-3*

Ayres Series

The Ayres series consists of light-colored, well-drained soils that are shallow to hardpan. These soils are mainly on alluvial fans at the base of the Powell Buttes, and here they were derived mostly from rhyolitic material washed out from the buttes, though their upper part was influenced by a layer of pumice as much as 12 inches deep in places. In other areas the Ayres soils developed from gravelly material mixed with pumice in the upper layers. The vegetation is mainly bluebunch wheatgrass, Sandberg bluegrass, needlegrasses, sagebrush, and scattered juniper.

The surface layer of Ayres soils is light brownish-gray gravelly sandy loam 4 to 9 inches thick. It has a low organic-matter content and is neutral. The subsoil is pale-brown clay loam that is 5 to 9 inches thick and is gravelly or stony in most places. Underlying the subsoil at a depth of 12 to 20 inches is a very hard, gravelly and cobbly hardpan, 4 to 25 inches thick. The hardpan is cemented with silica.

Ayres soils are used mainly for grazing and for dryfarmed small grain. Some areas are irrigated or are suitable for irrigation.

Ayres gravelly sandy loam, 2 to 6 percent slopes (AgB).—This soil is on alluvial fans and commonly occurs in long, narrow areas that extend from the base of the Powell Buttes and parallel the drainageways. Areas near the lower end of fans are almost oblong.

On the upper part of alluvial fans, this soil occurs below stony Ayres soils, and on the lower part it is surrounded by nearly level gravelly Ayres and Ochoco soils.

Representative profile:

0 to 8 inches, light brownish-gray gravelly sandy loam, dark grayish brown when moist; soft or slightly hard; neutral.
8 to 14 inches, brown gravelly clay loam; hard; neutral.
14 to 29 inches, pale-brown, gravelly and cobbly, indurated hardpan.
29 to 50 inches, light brownish-gray very gravelly and cobbly loam or sandy loam; lime in seams.

In a few small areas near the buttes, the surface layer when moist is very dark grayish brown or slightly darker. The depth to hardpan is 12 to 20 inches.

This soil has slow surface runoff. Under irrigation, it is moderately susceptible to erosion. Permeability is moderately slow in the subsoil and is very slow in the hardpan. The moisture-holding capacity and the fertility are low. Root growth is shallow. This soil is difficult to irrigate but is easy to work, though gravel commonly damages machinery.

About half the acreage is above the irrigation canal and is used mainly for grazing. Years ago a few areas were dryfarmed to wheat and then abandoned. These areas have been invaded by cheatgrass, rabbitbrush, and some sagebrush. Under irrigation, this soil is moderately well suited to alfalfa, potatoes, wheat, and barley, though the hardpan limits root growth. The soil is well suited to grasses and to Ladino, alsike, and red clovers for hay and pasture. *Capability unit IIe-5*

Ayres gravelly sandy loam, 6 to 12 percent slopes (AgC).—Almost all of this soil is above existing irrigation canals. The soil lies on the east and west sides of the Powell Buttes, just below areas of Searles soils, Elmore very stony loam, 6 to 40 percent slopes, and Ayres stony sandy loam, 6 to 20 percent slopes.

The soil is similar to Ayres gravelly sandy loam, 2 to 6 percent slopes. In several small areas near the Elmore soil, the surface layer is darker than in other areas and, when moist, is very dark grayish brown or slightly darker.

Surface runoff is slow to medium; nevertheless, the erosion hazard is severe where the soil is irrigated. The moisture-holding capacity is low. Because of slope and the gravel content, the soil is difficult to work and to irrigate.

Under irrigation, this soil is poorly suited to potatoes and other row crops. It is moderately well suited to sod and to close-growing crops. *Capability unit IIIe-4*

Ayres sandy loam, 2 to 6 percent slopes (AdB).—This soil is similar to Ayres gravelly sandy loam, 2 to 6 percent slopes, but it has few or no pebbles in the surface layer. It occurs on all parts of the Powell Buttes fan, generally at lower elevations than Ayres stony sandy loam, 0 to 6 percent slopes, and Ayres gravelly sandy loam, 2 to 6 percent slopes. Soils adjacent to this soil are Deschutes sandy loam, moderately deep over hardpan, 2 to 6 percent slopes, and Ayres and Ochoco sandy loams, 0 to 2 percent slopes.

This soil has low moisture-holding capacity. It is difficult to irrigate but is very easy to work. Erosion is a moderate hazard in irrigated areas.

About half of this soil is above present irrigation canals and is used mainly for grazing. A small acreage is dryfarmed to rye for hay or for grain. Crop suitability is the same as that of Ayres gravelly sandy loam, 2 to 6 percent slopes. *Capability unit IIe-5*

Ayres sandy loam, 6 to 12 percent slopes (AdC).—Most of this soil occurs near the base of the Powell Buttes and is above present irrigation canals. In many places it is next to gently sloping and sloping, stony and gravelly Ayres soils.

This soil is similar to Ayres gravelly sandy loam, 2 to 6 percent slopes, but it contains few or no pebbles in the surface layer. In several small areas near Elmore very stony loam, 6 to 40 percent slopes, the surface layer of this soil is darker than typical and, when moist, is very dark grayish brown or slightly darker.

Surface runoff is slow to medium. The moisture-holding capacity is low. Under irrigation, the soil is highly susceptible to erosion and is difficult to irrigate and slightly difficult to work. It is poorly suited to potatoes and other row crops but is moderately well suited to sod and other close-growing crops. *Capability unit IIIe-3*

Ayres stony sandy loam, 0 to 6 percent slopes (AmB).—This soil extends over much of the Powell Buttes fan. Above this soil are areas of Ayres stony sandy loam, 6 to 20 percent slopes, Elmore very stony loam, 6 to 40 percent slopes, and Searles soils. Below and adjacent to it are areas of gently sloping Ayres soils and of nearly level, gravelly and nongravelly Ayres and Ochoco soils. The soil has stony surface and subsurface layers, but in other respects it is similar to Ayres gravelly sandy loam, 2 to 6 percent slopes.

This soil has slow or very slow runoff and low moisture-holding capacity. Under irrigation, the soil is slightly to moderately erodible. It is very difficult to irrigate and to work, mainly because of stones.

Little of this soil is irrigated. Potatoes and other row crops are poorly suited to it, and alfalfa and small grain are only moderately well suited. Pasture is the best use. *Capability unit IVs-2*

Ayres stony sandy loam, 6 to 20 percent slopes (AmD).—Most of this soil occurs near the base of the Powell Buttes, below areas of Searles soils and above most areas of other Ayres soils. Slopes generally range from 6 to 12 percent but are as much as 20 percent in a few places.

Except for its stony surface and subsurface layers, this soil is similar to Ayres gravelly sandy loam, 2 to 6 percent slopes. In several areas near Elmore very stony loam, 6 to 40 percent slopes, the surface layer of this soil is very dark grayish brown when moist, or slightly darker.

Surface runoff is slow to medium. The moisture-holding capacity is low. In range areas the erosion hazard is moderate, but in irrigated fields it is severe. The soil is difficult to work and to irrigate because of stones and slope.

Under irrigation the soil is best suited to pasture, but only a small acreage is irrigated. *Capability unit VIe-1*

Ayres and Ochoco sandy loams, 0 to 2 percent slopes (AoA).—About half the acreage of this undifferentiated group of soils occurs on the outer reaches of the Powell Buttes fan and is below steeper Ayres soils. Most of the rest is east of Huston Lake and is above existing irrigation canals.

This unit consists of Ayres sandy loam, 0 to 2 percent slopes, and a soil that is like Ochoco sandy loam, 0 to 2 percent slopes, but has a hardpan at a depth of 20 to 30 inches. Except for having only a few or no pebbles in the surface layer, the Ayres soil is similar to Ayres gravelly sandy loam, 2 to 6 percent slopes. The depth to hardpan ranges from 12 to 20 inches.

On these soils surface runoff is very slow or slow, and the erosion hazard is only slight. The moisture-holding capacity is low in the Ayres soil and moderate in the Ochoco soil. The soils are easily worked, and the Ochoco soil can be irrigated without difficulty, but irrigation is slightly difficult on the Ayres soils.

Less than half of this unit is used for irrigated crops, and a small acreage is dryfarmed to rye for hay or for grain. Under irrigation, the Ayres soil is moderately well suited to potatoes, wheat, barley, and alfalfa. The Ochoco soil is well suited to potatoes, other row crops, small grain, and alfalfa. Both are good soils for grasses and red, alsike, and Ladino clovers grown for pasture or hay. In the Ayres soil the hardpan limits root growth of alfalfa and other deep-rooted plants. *Ayres soil: capability unit IIs-4; Ochoco soil: capability unit IIs-3*

Ayres and Ochoco sandy loams, 2 to 6 percent slopes (AoB).—The soils in this undifferentiated unit are Ayres sandy loam, 2 to 6 percent slopes, and Ochoco sandy loam, 2 to 6 percent slopes. The unit occurs in areas that generally range from 10 to 40 acres in size and commonly are next to areas of Ayres and Ochoco stony sandy loams, 0 to 6 percent slopes, Ayres and Ochoco sandy loams, 0 to 2 percent slopes, and Bakeoven soils.

Most of this unit is above existing irrigation canals and is used as range. Under irrigation, the Ayres soil is moderately well suited to potatoes, wheat, barley, and alfalfa, and it is well suited to grasses and to Ladino, alsike, and red clovers for hay and pasture. The Ochoco soil, under irrigation, is well suited to all crops grown in the survey area. *Ayres soil: capability unit IIe-5; Ochoco soil: capability unit IIe-3*

Ayres and Ochoco sandy loams, 6 to 12 percent slopes (AoC).—This undifferentiated unit covers only a small acreage in the survey area. It occurs in areas of 5 to 30 acres that are generally on short slopes just above drainageways. Ayres sandy loam, 6 to 12 percent slopes, and Ochoco sandy loam, 6 to 12 percent slopes, are the soils that make up the unit. These soils normally are deeper on the lower part of slopes than they are on the upper part. Included in areas mapped as these soils are a few small areas that have a loam surface layer.

Under irrigation, these soils are poorly suited to potatoes and other row crops, but they are moderately well suited to all other crops grown in the Area. *Capability unit IIIe–3*

Ayres and Ochoco sandy loams, 12 to 20 percent slopes (AoD).—This undifferentiated unit consists of Ayres sandy loam on 12 to 20 percent slopes, and Ochoco sandy loam on 12 to 20 percent slopes. It commonly occurs in long, narrow areas of 10 to 25 acres. These areas generally are 100 to 300 feet wide and 1,000 to 3,000 feet long.

The soils of this unit are highly susceptible to water erosion, though runoff is only medium. Wind erosion is a moderate hazard. The moisture-holding capacity is low in the Ayres soil and moderate in the Ochoco soil. Fertility in the Ayres soil is low, but in the Ochoco soil it is moderate. The soils are very difficult to irrigate and difficult to work.

Under irrigation, these soils are poorly suited to alfalfa and to potatoes and other row crops. They are best suited to pasture plants. *Capability unit IVe–1*

Ayres and Ochoco gravelly sandy loams, 0 to 2 percent slopes (ArA).—In this undifferentiated unit are Ayres gravelly sandy loam on 0 to 2 percent slopes, and Ochoco gravelly sandy loam on 0 to 2 percent slopes. These soils are mainly on the lower part of the Powell Buttes fan, below areas of steeper Ayres soils. Included in areas mapped as these soils are areas where the gravelly surface layer is fine sandy loam or loam.

Surface runoff is very slow on these soils and causes only a slight hazard of erosion. The moisture-holding capacity of the Ayres soil is low; that of the Ochoco soil is moderate. Fertility is low in the Ayres soil and is moderate in the Ochoco soil. These soils are slightly difficult to irrigate but are easy to work. Gravel, however, is likely to damage equipment, especially potato diggers.

Most of this unit is in irrigated crops. The soils are suited to the same crops as Ayres gravelly sandy loam, 2 to 6 percent slopes. *Ayres soil: capability unit IIs–4; Ochoco soil: capability unit IIs–3*

Ayres and Ochoco gravelly sandy loams, 6 to 20 percent slopes (ArD).—This undifferentiated unit occurs on terrace escarpments north of Prineville, along the Crooked River, and in the Lone Pine area. In most places the soils are on slopes only 150 to 400 feet long, and on the terraces above them are nearly level or gently sloping Ochoco soils. The unit consists of Ayres gravelly sandy loam on 6 to 12 and on 12 to 20 percent slopes, and Ochoco gravelly sandy loam on 6 to 12 and on 12 to 20 percent slopes. In about one-fourth of the acreage mapped as these soils, the surface layer is gravelly loam.

The soils of this unit have slow to medium runoff, but under irrigation, they are highly susceptible to erosion. They are difficult to irrigate and very difficult to work. The moisture-holding capacity is moderate. Little of the unit is cultivated. *Ayres soils: capability units IIIe–4 (6 to 12 percent slopes) and IVe–1 (12 to 20 percent slopes); Ochoco soils: capability units IIIe–3 (6 to 12 percent slopes) and IVe–1 (12 to 20 percent slopes)*

Ayres and Ochoco gravelly sandy loams, 20 to 40 percent slopes (ArE).—The soils in this undifferentiated unit are Ayres gravelly sandy loam, 20 to 40 percent slopes, and Ochoco gravelly sandy loam, 20 to 40 percent slopes. These soils are on the breaks, or bluffs, between the bottom lands and the terraces. In most places slopes are only 150 to 400 feet long.

In dryland areas these soils have medium to rapid surface runoff but are only slightly or moderately susceptible to erosion. Their moisture-holding capacity is low to medium. The soils are not suitable for irrigation or for dryfarming. They are best used as range. *Capability unit VIe–1*

Ayres and Ochoco stony sandy loams, 0 to 6 percent slopes (AsB).—This undifferentiated unit occurs in areas that range from 10 acres to several hundred acres in size and, in many places, adjoin the Bakeoven soils and other units of Ayres and Ochoco soils. The soils that make up this unit are Ayres stony sandy loam, 0 to 6 percent slopes, and Ochoco stony sandy loam, 0 to 6 percent slopes. In areas mapped as these soils, the surface layer is stony sandy loam in about two-thirds of the acreage, stony loam in less than 5 percent, and stony fine sandy loam in the rest.

Under irrigation, these soils are slightly or moderately susceptible to erosion. Because they are stony, they are slightly difficult or difficult to irrigate and are very difficult to work. Their moisture-holding capacity is low to moderate.

Nearly all the acreage of this unit is above existing canals. If water is made available, the soils are best suited to irrigated pasture. They are poorly suited to potatoes and other row crops. *Capability unit IVs–2*

Bakeoven Series

The Bakeoven series consists of light-colored, very shallow or shallow, well-drained soils that occur on the gently sloping upland plateau in the western part of the survey area. These soils developed on basalt bedrock under a cover of bunchgrasses, sagebrush, and juniper. They are very stony and commonly are called scabland soils.

The Bakeoven soils have a surface layer of grayish-brown, neutral very stony loam or very stony sandy loam 2 to 8 inches thick. The subsoil of brown to pale-brown very stony clay loam to very stony heavy loam is neutral and 4 to 10 inches thick. Basalt bedrock is within 6 to 12 inches of the surface.

These soils are mainly in range, but some areas are irrigated by wild flooding and used for pasture.

Bakeoven very stony loam, 0 to 20 percent slopes (BaD).—This soil commonly occurs on ridges above the Redmond and Deschutes soils. Slopes are mainly less than 6 percent.

Representative profile:

0 to 4 inches, grayish-brown very stony loam; soft; neutral.
4 to 11 inches, brown or pale-brown very stony heavy loam or very stony clay loam; slightly hard; neutral.
11 inches +, dark-colored vesicular basalt, commonly lime coated.

The surface layer is 2 to 5 inches thick. The depth to bedrock commonly is 6 to 12 inches but is as much as 18 inches in places. Included in a few areas mapped as this soil are small areas of stony Deschutes soils and of stony Redmond soils.

Surface runoff is very slow to medium. The moisture-holding capacity is very low, and permeability is moderately slow in the subsoil. The soil is very low in fertility and has a shallow or very shallow root zone. In range areas the erosion hazard is slight, but in irrigated areas it is moderate. Irrigating this soil is very difficult, and large stones make cultivation impractical.

This soil is used chiefly for range, but in the community of Powell Butte, the nearly level and gently sloping areas are irrigated by wild flooding and used for pasture (fig. 8). *Capability unit VIIs-2*

Bakeoven very stony sandy loam, 0 to 20 percent slopes (BbD).—This soil is similar to Bakeoven very stony loam, 0 to 20 percent slopes, but its surface layer is 4 to 8 inches of sandy loam that formed from windblown pumice. The subsoil is 4 to 10 inches thick. Depth to bedrock generally ranges from 8 to 12 inches, but in small areas it is as much as 18 inches. In a few areas mapped as this soil the surface layer is loamy sand. *Capability unit VIIs-2*

Borrow Pits (Bp)

This miscellaneous land type consists of areas from which gravel, sand, and other soil material have been removed for use in building roads and dams and for other purposes. These areas have little or no plant cover. *Capability unit VIIIs-1*

Boyce Series

The Boyce series consists of dark-colored, poorly drained or very poorly drained soils that occur on bottom land along Ochoco Creek east of Prineville and along the Crooked River northwest of the city. These soils formed in mixed alluvium that was derived mainly from basalt and partly from rhyolitic tuff and rhyolite. The water table was moderately high while the soils were forming, and it fluctuates between the surface and a depth of about 4 feet during most of the year.

The Boyce soils are nearly level but are cut by old stream channels in some areas. In spring they are frequently flooded and covered with fresh layers of silt. Generally, they were calcareous and contain alkali. The plant cover consists of willows, rushes, sedges, clovers, and annual grasses.

In cultivated areas the Boyce soils have a surface layer of grayish-brown silty clay loam, silt loam, or loam, 6 to 12 inches thick. This layer is mottled with reddish brown or dark olive gray. It is moderately calcareous and moderately alkaline.

The subsoil is 8 to 18 inches of grayish-brown clay loam or silty clay loam that is mottled with colors somewhat like those of the surface layer. Generally, it is calcareous in the upper part and noncalcareous in the lower part. The upper substratum is noncalcareous, gray silt loam, sandy loam, or sandy clay loam. It is 6 to 36 inches thick. The lower substratum occurs at a depth of 30 to 60 inches and consists of stratified gravel and sand.

Boyce silty clay loam (By).—This soil is in low, nearly level areas on the flood plain of streams. Although the areas generally are irregular in shape, they tend to be long and narrow and roughly parallel to the streams. They commonly range from 500 to 3,000 feet in length and from 200 to 600 feet in width. The lowest areas are commonly flooded for short periods in spring. In many places only a few feet higher than this soil are areas of Powder silt loam, Boyce silt loam, and Stearns silt loam.

Representative profile:

0 to 10 inches, grayish-brown silty clay loam mottled with reddish brown and dark olive gray; hard; moderately calcareous; moderately alkaline.

10 to 31 inches, grayish-brown, mottled clay loam becoming coarser with depth and changing to gray; hard; calcareous in the upper part; moderately or mildly alkaline; gradual to abrupt transition to underlying beds of stratified gravelly and sandy alluvium.

Some areas have spots that are slightly affected by alkali. Included in a few areas mapped as this soil are small areas of Boyce silt loam.

The natural drainage of this soil is poor. Runoff is very slow, and there is no erosion hazard. Permeability is moderately slow in the subsoil. Fertility and the moisture-holding capacity are high. Roots penetrate deeply. The soil is easy or fairly easy to irrigate but is fairly difficult or difficult to work.

This soil is best suited to plants used for hay and pasture. If it is drained, it is suited to potatoes, alfalfa, barley, and wheat. *Capability unit IIIw-1*

Boyce silt loam (Bs).—This soil occurs on nearly level flood plains in areas similar in shape to those of Boyce silty clay loam. In many places it is slightly above areas of Boyce silty clay loam but is below areas of Powder silt loam, Stearns silt loam, and Crooked sandy loam, 0 to 2 percent slopes. A few of the lower lying areas are often flooded for short periods in spring.

About 300 acres of this soil are strongly sodic. This acreage generally occurs in patches that are away from streams, are slightly higher than most of this soil, and are close to areas of Stearns silt loam and Crooked soils. Included in areas mapped as Boyce silt loam are some areas where the surface layer is loam and a few where it is fine sandy loam.

This soil has very slow runoff, is only slightly susceptible to erosion, and has poor natural drainage. The moisture-holding capacity and fertility are high. Root growth is deep. Irrigating and working the soil are easy or fairly easy.

This soil is best suited to shallow-rooted plants for hay and pasture. If adequate drainage is provided, and if alkali areas are reclaimed, the soil is suited to potatoes, alfalfa, and small grain. *Capability unit IIIw-1*

Boyce silt loam, ponded (Bw).—This soil is in oxbows, sloughs, and old stream channels where water stands on or at the surface most of the year. The soil is more mottled in the surface layer than Boyce silty clay loam, and generally it is free of lime and alkali. In a few small areas included with this soil, the surface layer is silty clay loam.

Natural drainage is very poor. Water ponds on the surface, and there is no erosion hazard. The moisture-holding capacity and the fertility are high. Roots penetrate to a moderate depth.

Figure 8.—Irrigated pasture on Bakeoven very stony loam, 0 to 20 percent slopes.

The plant cover on this soil consists mainly of willows and cattails, but grasses and sedges grow along the higher edges. Unless the soil is drained, it is too wet for cultivation and is not suited to crops other than water-tolerant plants used for pasture. If drained and leveled, the soil would be slightly difficult or difficult to irrigate. *Capability unit Vw–1*

Boyce loam, light-colored variant (Br).—Most of this soil is on the flood plain of McKay Creek and other small streams that drain through the terrace north of Prineville. The soil occurs in long, narrow areas that are 150 to 600 feet wide and ½ to 2 miles long. The surface layer is loam or silt loam, and the depth to sand and gravel ranges from 36 to more than 60 inches.

This soil is poorly drained. During much of the growing season, it is saturated with free water that causes a slight accumulation of alkali in the surface layer. Runoff is very slow, and erosion is not a hazard. The moisture-supplying capacity is very high or high, and fertility is high. Roots penetrate deeply. This soil is slightly difficult to irrigate and is difficult to work.

In undrained areas the plant cover is mainly cattails, rushes, sedges, saltgrass, and other water-loving plants. Unless the soil is adequately drained, it is poorly suited to all crops except those that are used for hay and pasture and are moderately tolerant of water. *Capability unit IIIw–1*

Courtrock Series

The Courtrock series consists of light-colored, well-drained soils that occupy alluvial fans, chiefly in the areas of Barnes Butte, Johnson Creek, McKay Creek, Lytle Creek, and Lone Pine. These soils were formed mainly in sediments derived from mixed basaltic and tuffaceous materials, but they have a small amount of pumice mixed into the surface layer. The principal plants are sagebrush, perennial grasses, and scattered juniper.

The Courtrock soils have a surface layer of light brownish-gray, neutral sandy loam, gravelly sandy loam, or stony sandy loam. The subsoil is brown to yellowish-brown heavy sandy loam to loam. Beneath the subsoil, at a depth of 30 to 36 inches, is light-brown to light yellowish-brown, calcareous gravelly sandy loam or gravelly loam. Sandy loam or gravelly sandy loam underlies these soils at a depth of about 50 inches.

Courtrock soils are used for irrigated crops, dryfarmed crops, and range.

Courtrock sandy loam, 2 to 6 percent slopes (CkB).—This soil is on alluvial fans, generally in areas of 10 to 40 acres. In many places it is adjacent to Prineville and Ochoco soils.

Representative profile:

0 to 30 inches, light brownish-gray sandy loam grading to pale-brown loam; soft or slightly hard; neutral in upper part and mildly alkaline in lower part.
30 to 50 inches, light-brown fine gravelly sandy loam to fine gravelly loam; slightly hard; calcareous; moderately alkaline.
50 inches +, light yellowish-brown, stratified and gravelly sandy loam; slightly hard; weakly calcareous; moderately alkaline.

In a few small areas the surface layer is loam, and in an area of about 40 acres it is clay loam.

This soil has slow surface runoff, but it is moderately susceptible to erosion if irrigated. Fertility and the moisture-holding capacity are moderate. The subsoil is moderately permeable, and roots penetrate deeply. This soil is very easily worked and can be irrigated with little difficulty.

Slightly less than half the acreage of this soil is below existing canals and is used for irrigated crops. The soil is well suited to potatoes, alfalfa, and all other crops grown in the survey area. *Capability unit IIe–2*

Courtrock sandy loam, 0 to 2 percent slopes (CkA).—This soil is similar to Courtrock sandy loam, 2 to 6 percent slopes. It occurs in areas of 10 to 40 acres that are above areas of Prineville sandy loam, 0 to 2 percent slopes, and Ochoco sandy loam, 0 to 2 percent slopes. Included in areas mapped as this soil are a few small areas that have a surface layer of loam.

This soil has very slow runoff and is subject to only slight erosion. It is very easy to irrigate and to work. Fertility and the moisture-holding capacity are moderate. Root penetration is deep.

Slightly more than half of this soil is below canals and is irrigated. Some of it above canals is dryfarmed to rye for hay or grain, and the rest is in range. This soil is well suited to all crops grown in the Area. *Capability unit IIs–5*

Courtrock sandy loam, 6 to 12 percent slopes (CkC).—This soil commonly occurs on the upper part of alluvial fans. In many places it is above Courtrock sandy loam, 2 to 6 percent slopes, and is below Gem very stony loam, 6 to 40 percent slopes, Gem-Searles stony loams, 6 to 40 percent slopes, and other soils on uplands.

This soil is similar to Courtrock sandy loam, 2 to 6 percent slopes. Included is a small acreage that has a loam surface layer and a few areas that are on slopes of as much as 20 percent.

On this soil runoff is slow to medium, but in irrigated areas the hazard of erosion is severe. The moisture-holding capacity and fertility are moderate. Roots penetrate deeply. The soil is difficult to irrigate and is slightly difficult to work.

Most of this soil is above present irrigation canals. A small acreage is planted to dryland rye for hay or grain, and the rest is in range. Under irrigation, the soil is best suited to close-growing plants used for pasture. It is moderately well suited to alfalfa and small grain but is poorly suited to potatoes because slopes are strong. *Capability unit IIIe–2*

Courtrock gravelly sandy loam, 0 to 2 percent slopes (CmA).—This soil has gravelly surface and subsurface layers but in other respects is similar to Courtrock sandy loam, 2 to 6 percent slopes. It generally occurs on the lower end of alluvial fans, just above areas of Powder loam, Metolius loam, 0 to 2 percent slopes, and other soils on flood plains.

This soil has very slow runoff and is only slightly susceptible to erosion. It is very easily irrigated and easily worked, though tillage is hindered by gravel. The moisture-holding capacity and fertility are moderate. Root growth is deep.

About three-fourths of this soil is irrigated, and most of the rest is dryfarmed to rye for hay or grain. The soil is well suited to all crops grown in the survey area. *Capability unit IIs–2*

Courtrock gravelly sandy loam, 2 to 6 percent slopes (CmB).—This soil is on alluvial fans, commonly above nearly level Courtrock soils and just below steeper ones. It is similar to Courtrock sandy loam, 2 to 6 percent slopes, but has gravelly surface and subsurface layers.

On this soil runoff is slow but, in irrigated areas, erosion is a moderate hazard. The moisture-holding capacity and fertility are moderate. Roots penetrate deeply. The soil is slightly difficult to irrigate and to work.

Most of this soil is above present irrigation canals. Of the dryland acreage, almost half is cultivated to rye for hay or grain, and the rest is in range. The soil is well suited to all crops grown in the Area. *Capability unit IIe–2*

Courtrock gravelly sandy loam, 6 to 12 percent slopes (CmC).—Most areas of this soil are at the head of alluvial fans, below areas of sloping to very steep soils on uplands. Except for gravel in the surface and subsurface layers, This soil is similar to Courtrock sandy loam, 2 to 6 percent slopes. Included in areas mapped as this soil are a few small areas that have a gravelly loam surface layer, and in some of these the slopes are as much as 20 percent.

Runoff is slow to medium, but the erosion hazard is severe if the soil is irrigated. Fertility and moisture-holding capacity are moderate. Root penetration is deep. The soil is difficult to irrigate and to work.

Most of this soil is above existing irrigation canals and has a cover of range plants. Under irrigation, the soil is best suited to close-growing plants used for pasture. It is moderately well suited to alfalfa and small grain but is poorly suited to potatoes. *Capability unit IIIe–2*

Courtrock stony sandy loam, 2 to 6 percent slopes (CoB).—This soil is similar to Courtrock sandy loam, 2 to 6 percent slopes, but has stones and cobbles throughout the profile. It occurs on alluvial fans, generally below areas of Rock land and Courtrock stony sandy loam, 6 to 20 percent slopes. Most of it is near the Crooked River south of Prineville.

Although runoff is slow, this soil is moderately susceptible to erosion if it is irrigated. It has moderate fertility and moisture-supplying capacity. Roots penetrate deeply. The soil is difficult to irrigate and very difficult to work.

Nearly all of this soil is in range. Under irrigation, the soil is best suited to close-growing pasture plants but is poorly suited to alfalfa, potatoes, and small grain. *Capability unit IVs-2*

Courtrock stony sandy loam, 6 to 20 percent slopes (CoD).—This soil is commonly at the head of alluvial fans below Rock land and Gem very stony loam, 6 to 40 percent slopes. In most places it is above Courtrock stony sandy loam, 2 to 6 percent slopes. Almost all the acreage is near the Crooked River south of Prineville and in the vicinity of Lone Pine.

This soil is like Courtrock sandy loam, 2 to 6 percent slopes, but it contains stones and cobbles throughout and is stony or very stony. Included in areas mapped as this soil are a few areas that have a stony loam surface layer.

Runoff is slow to medium, but if the soil is irrigated, the erosion hazard is moderate to severe. The moisture-holding capacity and fertility are moderate. Root penetration is deep. The soil is very difficult to irrigate and to work.

The soil is poorly suited to all irrigated crops except close-growing plants used for pasture. Practically all the acreage is in range. *Capability unit VIe-1*

Crooked Series

In the Crooked series are imperfectly drained soils that have a hardpan and are affected by alkali. These soils lie mainly on low benches along the Crooked River south and west of Prineville. They formed in moderately coarse textured or medium-textured alluvium derived mainly from pumice and partly from basaltic material. In many places a water table occurs just below the hardpan. The plant cover is mainly saltgrass, giant wildrye, greasewood, and rabbitbrush.

The surface layer is light brownish-gray sandy loam, fine sandy loam, loamy sand, or loam 4 to 6 inches thick. This layer is open and porous; it is strongly affected by alkali, is strongly or very strongly alkaline, and is slightly calcareous.

The subsoil is 6 to 30 inches thick and commonly is fine sandy loam but ranges from loam to loamy sand. It is open and porous but contains more alkali than the surface layer.

Underlying the subsoil at a depth of 12 to 36 inches is a strongly cemented hardpan that is 4 to 30 inches thick but generally is discontinuous. The hardpan probably formed at the water table or just above it. This layer restricts the movement of water and the penetration of roots. Below the hardpan is stratified fine sandy loam, very fine sandy loam, and loam.

The Crooked soils are irrigated and used for crops, hay, and pasture.

Crooked sandy loam, 0 to 2 percent slopes (CtA).—In many places this soil occurs just below terrace escarpments and along the edges of flood plains. It occupies areas of 5 to more than 100 acres that generally are 200 to 1,000 feet wide, 1,000 to 4,000 feet long, and irregular in shape. This soil is slightly higher and farther from stream channels than Boyce silt loam, Boyce silty clay loam, and Stearns silt loam.

Representative profile in a cultivated field:

0 to 13 inches, light brownish-gray sandy loam; soft; slightly calcareous; very strongly alkaline.

13 to 33 inches, light-gray to pale-brown hardpan, cemented strongly in upper part and less strongly in lower part; moderately calcareous; moderately or strongly alkaline.

33 to 60 inches, light brownish-gray, stratified fine and very fine sandy loam; slightly hard; moderately calcareous; strongly alkaline.

The surface layer is sandy loam or fine sandy loam. In a few small areas near Jap Creek and Lone Pine Flat, the subsoil is loam or sandy clay loam. The depth to hardpan ranges from 12 to 36 inches. The amount of alkali in this soil varies considerably from place to place; some fields are strongly affected and have many scalds, or barren spots. Included in areas mapped as this soil are a few small areas that have a loamy sand surface layer and are similar to this soil in alkali content.

This soil has very slow runoff, slow or very slow permeability, and low moisture-holding capacity. Because of its alkali content, it is difficult to irrigate and to work. Fertility is low. Root growth is shallow or only moderately deep because of the hardpan.

This soil is best suited to shallow-rooted plants grown for pasture and hay. It is moderately well suited to alfalfa and small grain but is poorly suited to potatoes. *Capability unit IIIw-2*

Crooked sandy loam, 2 to 6 percent slopes (CtB).—Most of this inextensive soil lies in long, narrow strips along the edge of the low bench northwest of Prineville. A few oblong tracts in the Jap Creek area range from 5 to 70 acres in size. In these positions the soil is affected by excess water that seeps into the subsoil from higher areas.

In many places this soil has a loam or sandy clay loam subsoil, but in alkali content and other respects it is similar to Crooked sandy loam, 0 to 2 percent slopes. In places the surface layer is loamy sand. The depth to the hardpan ranges from 12 to 36 inches.

This soil has slow runoff but is subject to moderate erosion if irrigated. It is difficult or very difficult to irrigate and is difficult to work. The moisture-holding capacity and fertility are low. Root growth is shallow or moderately deep.

Pasture plants and hay are the best suited crops. Alfalfa and small grain are moderately well suited, but potatoes are poorly suited. *Capability unit IIIw-2*

Crooked loamy sand, 0 to 2 percent slopes (CsA).—This soil commonly occurs in areas of 5 to 25 acres that are surrounded by other Crooked soils and by Stearns silt loam. It contains more pumice sand and is slightly browner than Crooked sandy loam, 0 to 2 percent slopes. The depth to hardpan is 20 to 36 inches.

This soil has slow or very slow runoff and is only slightly susceptible to erosion. Its moisture-holding capacity is low. Because the intake of water is more rapid than in other Crooked soils, reducing the alkali content by reclamation is fairly easy. The soil is slightly difficult or difficult to irrigate and is slightly difficult to work.

Plants grown for hay or pasture are best suited to this soil. Alfalfa and small grain are moderately well suited, but potatoes are poorly suited. *Capability unit IIIw-2*

Crooked loam, 0 to 2 percent slopes (CrA).—This soil occurs in irregularly shaped areas that generally are long and narrow and commonly range from 10 to 40 acres in size. In many places it is adjacent to areas of Boyce soils and Stearns silt loam.

This soil has a gray loam surface layer that is 6 inches thick and grades to a subsoil of grayish-brown loam. Underlying these layers is a hardpan at a depth of 16 to 30 inches.

Runoff is very slow, and the hazard of erosion is only slight. The moisture-holding capacity is moderate. This soil is difficult or very difficult to irrigate and is difficult to work. Because the surface layer and subsoil are medium textured, reducing their alkali content is difficult.

This soil is best suited to plants used for hay and pasture. It is moderately well suited to alfalfa and small grain but is poorly suited to potatoes. *Capability unit IIIw-2*

Day Series

The Day series is made up of red clays that occur on uplands and formed from clay of the John Day formation (*2*). Most of the plant cover is big sagebrush, annual grasses, bluebunch wheatgrass, and scattered juniper.

The surface layer is reddish-brown, granular, neutral clay 2 to 4 inches thick. The subsoil is reddish-brown clay that is very hard when dry and very sticky when wet. At a depth of 30 inches or more, the subsoil is calcareous. The substratum consists of red clay that is many feet thick and is weak in structure.

The Day soils shrink as they dry and form cracks that are 1 to 2 inches wide and, in some places, extend to a depth of 12 to 18 inches. Granular material from the surface layer falls into these cracks. When the soils again are wet, material from the subsoil is pushed upward as the cracks are closed by swelling. In many places this churning of the soil tends to move organic material downward and subsoil material and chips of lime toward the surface.

The Day soils are used as range.

Day clay, 6 to 40 percent slopes (DaE).—This soil occupies small tracts of 5 to 10 acres on irregular slopes. It is inextensive in the survey area and occurs mainly north and east of the Prineville terrace. Slopes generally range from 6 to 25 percent but are as much as 40 percent in some places.

Representative profile in a range area:

0 to 3 inches, reddish-brown clay; strong, fine, granular structure; very hard when dry, very sticky when wet; neutral.
3 to 31 inches, reddish-brown clay; hard when dry, very sticky when wet; neutral or mildly alkaline.
31 to 96 inches, red clay; weak structure; very hard when dry, very sticky when wet; hardness increases with depth; neutral or mildly alkaline.

This soil is well drained. It has slow to rapid runoff, is slowly permeable, and has moderate moisture-holding capacity. The fertility is moderate. Root growth is moderately deep.

Most of this soil is in range. The soil is not suitable for irrigation or for dryfarming. It is difficult to plow and can be tilled only within a narrow range of moisture content. *Capability unit VIIs-1*

Deschutes Series

The Deschutes series consists of sandy, light-colored, well-drained or somewhat excessively drained soils that were derived from pumice and developed under bunchgrasses. The pumice came from volcanic material that erupted from Mt. Mazama and other former volcanoes (*18*). In the Prineville Area these soils occur in the area of Powell Butte and westward to the Deschutes County line. They are porous, are low in organic-matter content, have a neutral surface layer and subsoil, and are rapidly or very rapidly permeable above the bedrock or other material that underlies them. The original plant cover consisted mainly of needlegrass, bluebunch wheatgrass, Indian ricegrass, sagebrush, and juniper.

Deschutes soils have a surface layer of light brownish-gray sandy loam or loamy sand 2 to 8 inches thick. Their subsoil is pale-brown sandy loam or loamy sand 5 to 10 inches thick. Both of these layers are neutral, soft, and pumicy.

The parent substratum is pale-brown or brown, neutral sandy loam or loamy sand that is 4 to 15 inches thick and is soft and pumicy. In many places the substratum is underlain by pale-brown very fine sandy loam, fine sandy loam, or light loam that contains a small amount of pumice. This layer generally is 6 to 12 inches thick, though it is as much as 30 inches thick in a few places. In some places it is calcareous. The depth to basalt bedrock or to gravel is normally 18 to 36 inches, but where these soils overlie soil material that is like an Ayres soil, the depth to hardpan is 30 to 54 inches.

Some areas of Deschutes soils are irrigated and used for crops, hay, and pasture. Part of the acreage is in range, and part is dryfarmed to small grain harvested for hay.

Deschutes sandy loam, 0 to 2 percent slopes (DnA).—This is the most extensive of the Deschutes soils. It occurs in areas that are 5 to several hundred acres in size and commonly lie in swales below areas of the very stony Bakeoven soils or below outcrops of basalt.

Representative profile:

0 to 11 inches, light brownish-gray sandy loam; soft; neutral.
11 to 15 inches, pale-brown sandy loam; soft; neutral.
15 to 23 inches, pale-brown light loam or fine sandy loam; hard; neutral or mildly alkaline.
23 inches +, basalt bedrock.

In most places this soil is underlain by basalt. In the Powell Butte area, however, some of it is underlain by tuffaceous sandstone. The depth to bedrock ranges from 18 to 30 inches.

This soil is well drained, is rapidly permeable, and has low moisture-holding capacity. Runoff is very slow, and the erosion hazard is only slight. Fertility is low. The growth of roots is moderately deep. The soil is very easy to irrigate and to work.

This soil is well suited to all crops grown in the survey area. *Capability unit IIs-1*

Deschutes sandy loam, 2 to 6 percent slopes (DnB).—This soil is extensive and, in many places, occurs between Redmond soils in swales and Bakeoven soils on ridges. Many areas of this soil range from 10 to 50 acres in size.

This soil generally is underlain by basalt, but some of it in the Powell Butte area is underlain by tuffaceous sandstone. Bedrock is 18 to 30 inches below the surface.

On this soil runoff is slow, permeability is rapid, and the moisture-holding capacity is low. The soil is moderately susceptible to erosion if irrigated. It is slightly difficult to irrigate and very easy to work. Fertility is low. Roots penetrate to a moderate depth.

All crops grown in the Area are well suited to this soil. *Capability unit IIe-1*

Deschutes sandy loam, 6 to 12 percent slopes (DnC).—Much of this fairly inextensive soil is in long, narrow areas that extend across the slope. These areas are 200 to 400 feet wide and 1,000 to 3,000 feet long. They generally range from 10 to 30 acres in size, and many of them lie below Bakeoven soils and outcrops of rock. A few areas of this soil are on slopes of as much as 20 percent. The depth to bedrock ranges from 18 to 24 inches.

This soil has slow to medium runoff but, if it is irrigated, is subject to severe erosion. It is rapidly permeable, has low moisture-holding capacity, and is low in fertility. Root growth is moderately deep. Irrigating this soil is difficult, and working it is slightly difficult.

Most of this soil is above irrigation canals and is used as range. The soil is best suited to pasture plants. If irrigated, it is moderately well suited to alfalfa and small grain. It is poorly suited to potatoes because it is sloping, shallow, and difficult to farm. *Capability unit IIIe-1*

Deschutes sandy loam, deep over basalt, 0 to 2 percent slopes (DsA).—This soil generally occurs in small areas of 5 to 25 acres. In many places the substratum is calcareous in the lower part. The depth to bedrock is 30 to 36 inches. Included in areas mapped as this soil are a few small tracts that have a surface layer of loamy sand.

This soil has very slow runoff and is only slightly susceptible to erosion. It is rapidly permeable, has moderate moisture-holding capacity, and is moderately fertile. Roots penetrate to a moderate depth. The soil is very easy to irrigate and to work.

This soil is well suited to all crops grown locally. Most of it is cultivated. *Capability unit IIs-1*

Deschutes sandy loam, deep over basalt, 2 to 6 percent slopes (DsB).—This inextensive soil occupies areas of 5 to 50 acres that are mainly east of the Powell Buttes. In many places the lower part of the substratum is calcareous. Bedrock is 30 to 36 inches below the surface. Included in areas mapped as this soil are a few large areas and a few small ones that have a loamy sand surface layer.

This soil has slow runoff but is moderately erodible if irrigated. Permeability is rapid, and the moisture-holding capacity and fertility are moderate. Root growth is moderately deep. The soil is slightly difficult to irrigate but is very easy to work.

This soil is well suited to all crops grown in the survey area. Much of the acreage is above existing irrigation canals. *Capability unit IIe-1*

Deschutes sandy loam, moderately deep over hardpan, 0 to 2 percent slopes (DoA).—This soil occurs on the lower end, or toe, of the Powell Buttes fan and adjoins nearly level or gently sloping Ayres soils and other Deschutes soils. Several areas of this soil are more than 100 acres in size. The largest is about 600 acres; it is irregular in shape and extends about 3 miles in an east-west direction.

This soil has upper layers like those of Deschutes sandy loam, 0 to 2 percent slopes, and lower layers somewhat like those of Ayres sandy loam, 0 to 2 percent slopes. The surface layer is 12 to 20 inches of pumicy sandy loam. Brown gravelly loam or gravelly clay loam underlies this layer, and a gravelly hardpan occurs at a depth of 30 to 42 inches.

On this soil runoff is very slow, and the hazard of erosion is slight. Permeability is moderately slow above the hardpan. The moisture-holding capacity and fertility are moderate. Root growth is moderately deep. The soil is very easy to irrigate and to work.

This soil is well suited to all crops grown locally. About half the acreage is irrigated; most of the rest is in range; and a small part is dryfarmed to rye that is harvested for hay. *Capability unit IIs-3*

Deschutes sandy loam, moderately deep over hardpan, 2 to 6 percent slopes (DoB).—This soil generally occupies areas of 5 to 50 acres that are below areas of Searles soils and sloping Ayres soils. It is similar to Deschutes sandy loam, moderately deep over hardpan, 0 to 2 percent slopes, and occurs above that soil in most places.

Although this soil has slow runoff, it is moderately erodible if irrigated. It has moderate moisture-holding capacity and is moderately fertile. It is very easily worked and can be irrigated with little difficulty.

This soil is well suited to all crops grown locally. Most of the acreage is higher than existing sources of irrigation water and is used mainly as range, but some of it is planted to rye for hay. *Capability unit IIe-3*

Deschutes sandy loam, moderately deep over hardpan, 6 to 12 percent slopes (DoC).—This inextensive soil is in areas of 5 to 25 acres that lie below areas of Searles soils and above nearly level or gently sloping Ayres soils. It is similar to Deschutes sandy loam, moderately deep over hardpan, 0 to 2 percent slopes.

Runoff is slow to medium. If the soil is irrigated, however, the erosion hazard is severe. Fertility and moisture-holding capacity are moderate. The soil is difficult to irrigate and slightly difficult to work.

All of this soil is above existing canals, though it could be irrigated if water were available. Under irrigation, the soil is best suited to close-growing plants used for pasture. It is moderately well suited to alfalfa and small grain but is poorly suited to potatoes. *Capability unit IIIe-3*

Deschutes sandy loam, deep over hardpan, 0 to 2 percent slopes (DpA).—This soil occupies only a small acreage and is mainly in slight depressions on the north side of the Powell Buttes fan. Its upper layers are pumicy sandy loam 30 inches or more thick. The depth to hardpan is 42 to 54 inches.

This soil has very slow runoff and is only slightly susceptible to erosion. It has rapid permeability, moderate moisture-holding capacity, and moderate fertility. It is very easy to irrigate and to work.

All crops grown in the Area are well suited to this soil. *Capability unit IIs-3*

Deschutes sandy loam, moderately deep over gravel, 0 to 2 percent slopes (DrA).—This soil occurs in shallow drainageways at the toe of the Powell Buttes fan. It consists of 24 to 30 inches of pumicy sandy loam underlain by mixed gravelly material. The underlying material washed from slopes of the Powell Buttes and consists of loam to clay loam that is gravelly, cobbly, or stony and, in many places, is calcareous. Otherwise, this soil is like Deschutesandy loam, moderately deep over hardpan, 0 to 2 perscent slopes.

This soil has very slow runoff and is only slightly susceptible to erosion. It is rapidly permeable, has moderate moisture-holding capacity, and is moderately fertile. It is very easy to irrigate and to work.

All crops grown locally are well suited to this soil. *Capability unit IIs-1*

Deschutes sandy loam, moderately deep over gravel, 2 to 6 percent slopes (DrB).—This soil occurs in dry, long and narrow drainageways on the Powell Buttes fan. Most areas range from 10 to 30 acres in size and are 150 to 400 feet wide. A few small areas have slopes of as much as 12 percent. The profile of this soil is similar to that of Deschutes sandy loam, moderately deep over gravel, 0 to 2 percent slopes.

This soil has slow runoff, but irrigated fields are moderately susceptible to erosion. It is rapidly permeable and has moderate moisture-holding capacity and fertility. The soil is slightly difficult to irrigate but is very easy to work.

Although this soil is well suited to all crops grown locally, most of it is above present irrigation canals and is used as range. *Capability unit IIe-1*

Deschutes stony sandy loam, 0 to 2 percent slopes (DtA).—This soil occurs in the Powell Butte area and is in tracts of 5 to 50 acres that lie below areas of Bakeoven soils and Rock land. The depth to bedrock ranges from 18 to 24 inches.

On this soil runoff is very slow, permeability is rapid, and the hazard of erosion is only slight. The moisture-holding capacity and fertility are low. The soil is slightly difficult to irrigate and, because it is stony, is very difficult to work. Stones may damage machinery and interfere with smoothing and leveling.

This soil is best suited to pasture but is poorly suited to row crops and small grain. Much of the acreage is above existing irrigation canals. *Capability unit IVs-2*

Deschutes stony sandy loam, 2 to 6 percent slopes (DtB).—This soil is 18 to 24 inches deep over bedrock. It generally occurs in areas of 5 to 40 acres below Bakeoven soils and Rock land. About 10 percent of the acreage is very stony.

Runoff is slow, and permeability is rapid. The erosion hazard is moderate in irrigated fields. Fertility and the moisture-holding capacity are low. The soil is difficult to irrigate and very difficult to work.

Only a small acreage of this soil is irrigated. The soil is best suited to plants used for pasture, but it is poorly suited to row crops and small grain. *Capability unit IVs-2*

Deschutes stony sandy loam, 6 to 20 percent slopes (DtD).—This soil occupies areas of 5 to 25 acres below areas of Rock land and outcrops of basalt. It is 18 to 24 inches deep over basalt bedrock.

This soil has slow to medium runoff, but irrigated fields are subject to severe erosion. It is rapidly permeable, has low moisture-holding capacity, and is low in fertility. It is very difficult to irrigate and to work. The soil is poorly suited to all irrigated crops except plants grown for pasture. *Capability unit VIe-1*

Deschutes loamy sand, 0 to 2 percent slopes (DcA).—This soil consists of 18 to 30 inches of pumiceous loamy sand over basalt or other bedrock. In most places it adjoins Bakeoven soils and Deschutes-Bakeoven sandy loams, 0 to 6 percent slopes. Many areas of this soil range from 5 to 10 acres in size, and only a few are larger than 40 acres.

This soil is somewhat excessively drained. It has very slow runoff and is only slightly susceptible to water erosion, but it is moderately erodible by wind unless protected. It has rapid or very rapid permeability and low moisture-holding capacity. Because infiltration is rapid, the soil is slightly difficult to irrigate, but it is very easy to work. The fertility is low. Root growth is moderately deep.

Most of this soil is above existing irrigation canals and is used mainly as range. The soil is well suited to all crops grown in the Area. *Capability unit IIIs-1*

Deschutes loamy sand, 2 to 6 percent slopes (DcB).—This soil generally occurs in areas of 5 to 10 acres that are 100 to 300 feet wide. Only a few areas are larger than 40 acres. In many places the soil lies below Bakeoven soils or Rock land and above nearly level Redmond soils in basins and nearly level Deschutes sandy loam. The profile of this soil is similar to that of Deschutes loamy sand, 0 to 2 percent slopes.

This soil has very slow runoff, but it is moderately susceptible to water erosion if irrigated. The hazard of wind erosion is moderate. Permeability is very rapid, and the moisture-holding capacity is low. The soil is very easy to work but is difficult to irrigate because of slope and rapid infiltration. Fertility is low.

Although this soil is well suited to all crops grown locally, most of it is above present irrigation canals and is used mainly as range. *Capability unit IIIs-1*

Deschutes loamy sand, 6 to 20 percent slopes (DcD).—Most of this soil is in areas of 5 to 15 acres that lie in deep draws and below areas of Bakeoven soils and outcrops of basalt rock. About 10 percent of the acreage is on slopes of 20 to 40 percent. The profile of this soil is similar to that of Deschutes loamy sand, 0 to 2 percent slopes.

This soil has very slow runoff but, if irrigated, it is subject to severe erosion by water. The hazard of wind erosion is moderate. The soil is very rapidly permeable, has low moisture-holding capacity, and is low in fertility. It is slightly difficult to irrigate and is slightly difficult or difficult to work.

Nearly all of this soil is above existing irrigation canals and is mainly in range. The soil is best suited to dryland grasses and other range plants and to close-growing plants used for irrigated pasture. It is poorly suited to potatoes. *Capability unit IVs-1*

Deschutes loamy sand, moderately deep over hardpan, 0 to 2 percent slopes (DdA).—This soil occupies areas of 5 to 80 acres on the Powell Buttes fan. It occurs near Deschutes sandy loam, moderately deep over hardpan, 0 to 2 percent slopes, and Deschutes loamy sand, moderately deep over hardpan, 2 to 6 percent slopes.

Except for the texture of its upper layers, this soil is like Deschutes sandy loam, moderately deep over hardpan 0 to 2 percent slopes. The upper layers are like those of Deschutes loamy sand and are about 20 inches thick. In most places the lower layers of this soil are like the subsoil of Ayres gravelly sandy loam. They are underlain by a hardpan at a depth of 30 to 36 inches. In a few places the lower layers are missing, and the pumicy upper layers directly overlie the hardpan.

This soil is well drained. It has slow or very slow runoff and is only slightly susceptible to water erosion, but the hazard of wind erosion is moderate. The soil has moderately slow permeability and is moderate in fertility and moisture-holding capacity. It is easily irrigated and very easily worked.

This soil is well suited to all crops grown in the Area but most of it is in range. *Capability unit IIIs-1*

Deschutes loamy sand, moderately deep over hardpan, 2 to 6 percent slopes (DdB).—This inextensive soil occupies areas that range from 5 to more than 100 acres in size. It occurs near Deschutes loamy sand, moderately deep over hardpan, 0 to 2 percent slopes, and it is similar to that soil but is 30 to 42 inches deep to hardpan. About 10 percent of the acreage is on slopes of 6 to 20 percent.

This well-drained soil has slow runoff, moderately slow permeability, and moderate moisture-holding capacity. It is moderately susceptible to both wind and water erosion. It is easily worked but cannot be irrigated easily. The fertility is moderate.

This soil is well suited to all crops grown locally. Most of it is used as range. *Capability unit IIIs-1*

Deschutes stony loamy sand, 0 to 6 percent slopes (DmB).—This soil consists of 18 to 24 inches of stony, pumiceous loamy sand over basalt or other bedrock. It generally occurs in areas of less than 5 to 25 acres, though a few areas are larger than 40 acres. In many places this soil adjoins areas of Rock land and Bakeoven soils.

This soil is somewhat excessively drained. It has very slow runoff, very rapid permeability, and low moisture-holding capacity. It is moderately susceptible to wind erosion and, if irrigated, is subject to slight or moderate washing. Fertility is low. The soil is very difficult to irrigate and to work.

This soil is poorly suited to row crops and small grain. It is best used for pasture. *Capability unit IVs-2*

Deschutes-Bakeoven sandy loams, 0 to 6 percent slopes (DvB).—This complex is made up of Deschutes sandy loams and Bakeoven very stony sandy loam in about equal acreages. The Deschutes soils are on 0 to 2 and on 2 to 6 percent slopes, and the Bakeoven soil is on 0 to 6 percent slopes. These soils are so closely intermingled that mapping them separately is impractical. Areas of the complex range from 10 to 100 acres in size, and more than half of them are larger than 25 acres. About three-fourths of the acreage lies west of the Dry River.

The Deschutes soils were derived from pumice and are 18 to 30 inches deep. They occur in small pockets or basins within areas of Bakeoven very stony sandy loam. The Bakeoven soil was derived from basalt bedrock and is only 8 to 12 inches deep.

Runoff is slow or very slow on the Deschutes soils and is slow on the Bakeoven soil. The moisture-holding capacity and fertility are low for the Deschutes soils and are very low for the Bakeoven soil. All the soils are only slightly susceptible to erosion.

Although the Deschutes soils are suitable for cultivation, the soils of the complex are so intermingled that irrigating them is very difficult. *Deschutes soils: capability units IIs-1 (0 to 2 percent slopes) and IIe-1 (2 to 6 percent slopes); Bakeoven soil: capability unit VIIs-2*

Deschutes-Bakeoven very stony sandy loams, 0 to 6 percent slopes (DuB).—This complex has a small total acreage and occupies only a few areas, which range from 15 to 30 acres in size. The complex is similar to Deschutes-Bakeoven sandy loams, 0 to 6 percent slopes, but the soils are so stony that they are commonly called scabland, and the Deschutes soil is 18 to 24 inches deep instead of 18 to 30 inches deep.

Runoff is slow or very slow on the Deschutes soil and is slow on the Bakeoven soil. In the Deschutes soil the moisture-holding capacity and fertility are low; in the Bakeoven soil they are very low. Both soils are only slightly susceptible to erosion.

These soils are not suitable for cultivation but can be used for range. *Capability unit VIIs-2*

Elmore Series

The Elmore series consists of well-drained, moderately dark colored soils on hilly and steep uplands. These soils were derived from rhyolite and developed under a cover of Idaho fescue, bluebunch wheatgrass, sagebrush, and bitterbrush.

The surface layer of the Elmore soils is slightly acid, grayish-brown to dark grayish-brown very stony loam 5 to 10 inches thick. The subsoil of dark-brown heavy loam to clay loam is very stony and is slightly calcareous in the lower part. Rhyolite bedrock occurs at a depth of 2 to 5 feet. It is nearest the surface on hilltops and is at the greatest depth toward the foot of steep slopes.

The Elmore soils are in range.

Elmore very stony loam, 6 to 40 percent slopes (EmE).—This soil is at elevations above 3,400 feet on the east and north slopes of the Powell Buttes. It generally occupies areas that range from 50 to 400 acres in size. Slopes ordinarily range from 20 to 40 percent and vary considerably in length. In many places they are 300 to 2,000 feet long.

Representative profile:

0 to 9 inches, grayish-brown very stony loam; soft or slightly hard; slightly acid.
9 to 50 inches, dark-brown, very stony heavy loam to clay loam; slightly hard or hard; slightly acid to mildly alkaline; slightly calcareous in seams and nodules in lower part.
50 inches +, rhyolite rock.

This soil has slow to rapid runoff, and it is likely to erode moderately or severely if unprotected. It is moderately slow in permeability and has moderate moisture-holding capacity and fertility. The growth of roots is moderately deep or deep.

Because this soil contains many stones and is strongly sloping to steep, it is not suitable for cultivation. Its best use is range. *Capability unit VIIs-4*

Forester Series

The Forester series consists of light-colored, imperfectly drained soils that are sandy in the surface layer and subsoil and are affected by alkali. These soils occupy low, nearly level terraces along the Crooked River near Prineville. They developed in alluvium derived mainly from pumice under a cover of greasewood and saltgrass.

The Forester soils have a light brownish-gray sandy loam or loamy sand surface layer 4 to 8 inches thick. It is calcareous, slightly to strongly alkali, and high in content of pumice. The upper subsoil is similar to the surface layer but is 4 to 12 inches thick. Pale-brown sandy loam or loamy sand makes up the lower subsoil below a depth of 8 to 20 inches. The underlying material is stratified silt loam to sandy loam. In some places alluvial layers below a depth of 2½ to 6 feet are low in pumice content.

Forester soils are used for irrigated crops, hay, and pasture.

Forester loamy sand (Fo).—This soil occurs in areas that range from less than 5 to 50 acres in size. Most areas are nearly level, but a few small ones are gently sloping.

Representative profile:

0 to 12 inches, light brownish-gray loamy sand; soft; very strongly alkaline; moderately or strongly calcareous.
12 to 27 inches, pale-brown loamy sand; soft; strongly or very strongly alkaline; strongly calcareous.
27 to 48 inches, pale-brown very fine sandy loam; slightly hard or hard; strongly alkaline; moderately calcareous.
48 inches +, pale-brown, stratified silt loam to sandy loam; slightly hard or hard; strongly alkaline; moderately calcareous.

In many places this soil is slightly affected by alkali. Runoff is very slow, and the hazard of water erosion is only slight, but the soil blows easily if it is left unprotected when dry. In an area near O'Neil, sandy material from this soil has drifted into hummocks around shrubs. Permeability is very rapid, and the moisture-holding capacity and fertility are low. Although the soil is easily penetrated by plant roots, it is slightly difficult to irrigate and to work.

This soil is best suited to plants grown for hay and pasture. It is moderately well suited to alfalfa and small grain and is poorly suited to potatoes. *Capability unit IIIw-2*

Forester sandy loam (Fr).—This soil is mainly in nearly level areas of 5 to 50 acres. It is similar to Forester loamy sand but has a sandy loam surface layer. The accumulation of alkali in this soil ranges from slight to strong, and it can increase rapidly. Areas that have many barren spots are strongly affected by alkali.

Under irrigation, this soil is only slightly susceptible to erosion. It has very slow runoff, rapid permeability, and moderate moisture-holding capacity. Fertility is moderate. The soil is slightly difficult to work and, because of its alkali content, is slightly difficult to irrigate.

This soil is best suited to plants used for hay and pasture. It is moderately well suited to alfalfa and small grain but is poorly suited to potatoes. *Capability unit IIIw-2*

Gem Series

In the Gem series are rolling to steep, moderately dark colored, stony soils that developed from material weathered from basalt. These soils are mainly in the Lone Pine area, on the watersheds of McKay and Johnson Creeks, and in the area south of Prineville. The original plant cover consisted chiefly of Idaho fescue, bluebunch wheatgrass, sagebrush, bitterbrush, and scattered juniper.

The Gem soils have a surface layer of grayish-brown stony loam, very stony loam, or stony clay loam, 4 to 8 inches thick. This layer has granular structure and is slightly acid or neutral. The subsurface layer is grayish-brown, neutral very stony loam or very stony clay loam 4 to 10 inches thick. The subsoil is brown to light yellowish-brown stony or very stony clay loam that is hard when dry and is not readily permeable to water and roots. Basalt bedrock occurs at a depth of 1 to 3 feet.

These soils are used as rangeland.

Gem very stony loam, 6 to 40 percent slopes (GbE).—Nearly half the acreage of this soil is in the Lone Pine area. The rest is in the watersheds of McKay and Johnson Creeks and in an area south and east of Prineville. Most areas of this soil range from 30 to 100 acres in size, but a few are larger than 200 acres.

Representative profile:

0 to 9 inches, grayish-brown very stony loam; hard; slightly acid or neutral.
9 to 20 inches, brown to dark-brown stony clay loam; hard; neutral or mildly alkaline.
20 to 28 inches, brown stony clay loam; hard; neutral to moderately alkaline; calcareous in the lower part.
28 inches +, basalt rock.

The surface layer is slightly darker on northerly slopes than it is on southerly slopes. The depth to bedrock ranges from 12 to 26 inches.

On this soil runoff is slow to rapid, permeability is moderately slow, and the hazard of erosion is moderate to severe. The soil has low to moderate fertility and moisture-holding capacity. Root growth is shallow to moderately deep.

This soil is above irrigation canals and is used for grazing in spring and fall. It is not suitable for cultivation. *Capability unit VIIs-4*

Gem stony loam, 6 to 20 percent slopes (GaD).—This inextensive soil is commonly in areas 5 to 30 acres in size. It is less stony than Gem very stony loam, 6 to 40 percent slopes, but in other respects is similar to that soil.

On this soil runoff is slow to medium, and the erosion hazard is moderate. The moisture-holding capacity and fertility are low to moderate.

This soil is not suitable for irrigation. It is difficult to cultivate but can be reseeded. *Capability unit VIe-2*

Gem-Day stony clay loams, 12 to 40 percent slopes (GcE).—Nearly all of this complex is in the McKay Creek watershed north of Prineville. One area accounts for about half the total acreage.

About three-fourths of the complex is Gem stony clay loam, and the rest is Day clay. These soils are mapped together because they are so closely intermingled. Except for texture of the surface layer, the Gem soil is similar to Gem very stony loam, 6 to 40 percent slopes.

The soils of this complex have medium to rapid runoff and are moderately to highly erodible. Permeability is moderately slow in Gem stony clay loam and is slow in Day clay. These soils are not suitable for cultivation, because slopes are steep. In addition, the Gem soil is stony, and the Day is clayey. The soils are best used for grazing, but the cover of grass and other plants is more sparse on the Day soil than on the Gem soil. *Gem soil: capability unit VIe-2; Day soil: capability unit VIIs-1*

Gem-Searles stony loams, 6 to 40 percent slopes (GgE).—The soils in this complex are so closely intermingled that mapping them separately is not practical. Gem stony loam accounts for 60 percent or more of the acreage, and Searles stony loam makes up the rest. The Gem soil is similar to Gem very stony loam, 6 to 40 percent slopes, but it is less stony.

The soils of the complex have slow to rapid runoff; they are moderately or highly susceptible to erosion. Their moisture-holding capacity and fertility are low to moderate.

This complex is used as rangeland. *Gem soil: capability unit VIe-2; Searles soil: capability unit VIe-1*

Lamonta Series

The Lamonta series consists of well-drained soils on alluvial fans that have a moderately dark colored surface layer and a clay subsoil underlain by a hardpan. These soils developed in alluvium that washed from soils derived from rhyolite, tuff, and basalt. The plant cover is mainly sagebrush, bluebunch wheatgrass, and scattered juniper.

The Lamonta soils have a surface layer of light brownish-gray loam, gravelly loam, or stony loam, 4 to 8 inches thick. This layer is granular in structure and is neutral.

The upper subsoil is brown, slightly acid clay 2 to 8 inches thick. The lower subsoil of brown, yellowish-brown, or reddish-brown clay is mildly alkaline and, in many places, is gravelly. Underlying the subsoil at a depth of 18 to 30 inches is a gravelly, indurated hardpan that generally is 20 inches or more thick.

In the Prineville Area the Lamonta soils are northwest of Lytle Creek and occupy less than 640 acres. Some areas are irrigated and used for crops, hay, and pasture, and some are in range.

Lamonta gravelly loam, 6 to 12 percent slopes (LgC).—This soil is at the upper end, or head, of alluvial fans. In most places it lies below the Searles soils and adjoins Lamonta stony loam, 6 to 20 percent slopes. In the Prineville Area only a few tracts have been mapped; these range from 5 to 50 acres in size.

Representative profile:

0 to 7 inches, light brownish-gray gravelly loam; slightly hard; neutral.
7 to 23 inches, brown clay; hard; mainly neutral, but mildly alkaline in the lower 3 inches.
23 to 36 inches +, pale-brown to light-gray, indurated, gravelly hardpan cemented with silica.

The depth to hardpan ranges from 18 to 30 inches. Included in areas mapped as this soil are areas that have a gravelly clay loam surface layer and make up about 5 percent of the acreage. In addition, less than 5 percent of the included acreage has a fine sandy loam surface layer, and a small acreage is on slopes of 12 to 20 percent.

This soil has slow to medium runoff and is slowly permeable. The erosion hazard is moderate in dryland areas but is severe in irrigated fields. The moisture-holding capacity and fertility are moderate. Root growth is shallow to moderately deep. The soil is difficult to irrigate and to work.

Most of this soil is just above existing canals, but it could be irrigated if water were available. Under irrigation, the soil is moderately well suited to small grain and to plants grown for hay and pasture. It is poorly suited to alfalfa and to potatoes and other row crops. *Capability unit IIIe-4*

Lamonta loam, 0 to 6 percent slopes (LaB).—This inextensive soil is in areas of less than 5 to 25 acres that occur at the lower end, or toe, of alluvial fans and are below other Lamonta soils. The soil lacks gravel in the surface layer, but in other respects it has a profile similar to that of Lamonta gravelly loam, 6 to 12 percent slopes. Hardpan is 18 to 30 inches below the surface.

This soil has slow or very slow runoff. It is only slightly erodible in dryland areas but is subject to slight or moderate erosion if irrigated. It has moderate moisture-holding capacity and fertility. Root growth is moderately deep. The soil is slightly difficult to irrigate and is easy or slightly difficult to work.

This soil is poorly suited to potatoes but is moderately well suited to small grain and to alfalfa and other plants grown for hay and pasture. *Capability unit IIe-4*

Lamonta stony loam, 6 to 20 percent slopes (LmD).—This soil occurs at the head of alluvial fans. It lies below Searles and Gem soils and, in many places, is next to Lamonta gravelly loam, 6 to 12 percent slopes. About three-fourths of the total acreage is in two areas of 60 to 80 acres each.

This soil has stones throughout the profile, but in other respects it is similar to Lamonta gravelly loam, 6 to 12 percent slopes. The depth to hardpan ranges from 18 to 30 inches. Included in areas mapped as this soil are areas that have a stony clay loam surface layer and that make up about 15 percent of the total acreage.

Runoff is medium, and erosion is a moderate hazard. Fertility and moisture-holding capacity are low. Root growth is moderately deep. The soil is very difficult to work and is not suitable for irrigation. Its best use is range. *Capability unit VIe-1*

Lookout Series

The Lookout series consists of well-drained, light-colored, generally stony soils that have a loam surface layer and a clay subsoil over a strongly cemented hardpan. These soils lie above and below rimrock escarpments on uplands in Swartz Canyon, on Combs Flat, and along Jap, McKay, and Johnson Creeks. They developed from material weathered from basalt under a cover of bluebunch wheatgrass, Sandberg bluegrass, sagebrush, juniper, and other plants.

The Lookout soils have a 5- to 12-inch surface layer of light brownish-gray, neutral loam, stony loam, or very stony loam. The upper subsoil, 8 to 16 inches thick, is grayish-brown to brown clay or heavy clay loam that is stony or very stony. It is neutral or mildly alkaline and is hard when dry. The lower subsoil is a 2- to 8-inch layer of yellowish-brown or light yellowish-brown clay. This is moderately alkaline and calcareous. Below the subsoil is a strongly cemented hardpan that is 2 to 18 inches thick and overlies basalt bedrock at a depth ranging from 18 to 36 inches.

Lookout soils are used for range and for dryland crops.

Lookout very stony loam, 0 to 40 percent slopes (LvE).—This soil accounts for about 70 percent of the total acreage of Lookout soils. It is on nearly level plateaus and on steep side slopes along drainageways that dissect the plateaus. The largest area is in the vicinity of Swartz Canyon and is larger than 640 acres in size. Most other areas range from 10 to 100 acres.

Representative profile:

0 to 8 inches, light brownish-gray very stony loam; slightly hard; neutral.
8 to 20 inches, brown very stony clay; hard when dry, very sticky when wet; mainly neutral or mildly alkaline, but moderately alkaline and calcareous in lower 2 inches.
20 to 30 inches, pale-brown hardpan strongly cemented with silica.
30 inches +, basalt bedrock.

In the steepest areas the subsoil has less clay than in other areas and the hardpan is softer. The depth to hardpan generally ranges from 18 to 30 inches, but on some of the steepest slopes the hardpan is missing. Included in areas mapped as this soil are a few small areas that have a sandy loam or a fine sandy loam surface layer.

This soil has very slow to rapid runoff, and the hazard of erosion is slight to severe. Permeability is slow, and the moisture-holding capacity and fertility are low. Stones prevent the use of tillage implements, but the soil is suited to range. *Capability unit VIIs-1*

Lookout stony loam, 0 to 6 percent slopes (LsB).—This soil generally occurs in areas of 10 to 50 acres. In many places it adjoins Lookout very stony loam, 0 to 40 percent slopes, and Lookout stony loam, 6 to 20 percent slopes. The depth to hardpan ranges from 18 to 30 inches. Included in areas mapped as this soil are a few small areas with a sandy loam or a clay loam surface layer.

On this soil runoff is very slow or slow, and the erosion hazard is slight or moderate. The moisture-holding capacity and fertility are low to moderate. The soil has very poor workability and is not suited to irrigation. It is useful only as rangeland. *Capability unit VIe-1*

Lookout stony loam, 6 to 20 percent slopes (LsD).—Nearly half the acreage of this soil is near Jap Creek. Most tracts are 20 to 30 acres in size, but a few are smaller and a few are 80 acres or more. The depth to hardpan ranges from 18 to 30 inches. Areas mapped as this soil include a few small areas that have a sandy loam surface layer.

On this soil medium runoff causes a moderate erosion hazard. Fertility and the moisture-holding capacity are low to moderate. The soil has very poor workability and is not suitable for cultivation. It is used entirely for grazing. *Capability unit VIe-1*

Lookout loam, 0 to 2 percent slopes (LoA).—All of this soil is in the Combs Flat area and lies on the plateau above stony and very stony Lookout soils. The few tracts in the Area range from 10 to more than 100 acres in size.

The subsoil of this soil has slightly less clay and, in most places, is thicker than that of Lookout very stony loam, 0 to 40 percent slopes. In addition, the surface layer is thicker and contains few or no stones. The depth to bedrock ranges from 24 to 36 inches. Included in areas mapped as this soil are a few areas that have a sandy loam surface layer.

On this soil runoff is very slow, and erosion is only a slight hazard. The moisture-holding capacity and fertility are moderate. Root penetration is moderately deep. Although the soil is slightly difficult to work, it would be easy to irrigate if water were available.

This soil is above present irrigation canals, and much of it has been dryfarmed to rye for grain or hay. Under irrigation, the soil would be poorly suited to potatoes but well suited to all other crops grown in the Area. *Capability unit IIe-4*

Lookout loam, 2 to 6 percent slopes (LoB).—This soil is mostly in the areas of Combs Flat and Jap Creek. Only a few tracts occur; they range from 10 to 80 acres in size. The soil profile and its variations are similar to those of Lookout loam, 0 to 2 percent slopes. Included in areas mapped as this soil are a few areas that have a surface layer of sandy loam or clay loam.

This soil has slow runoff, and it is only slightly susceptible to erosion in dryland areas. If it is irrigated, however, there is a moderate risk of erosion. The moisture-holding capacity and fertility are moderate. Working this soil is slightly difficult, and irrigating it would be slightly difficult if water were available.

This soil is above existing irrigation canals and, in the Combs Flat area, some of it has been cultivated to dryland rye for grain or hay. Under irrigation, it is well suited to most crops grown locally but is poorly suited to potatoes. *Capability unit IIe-4*

Metolius Series

The Metolius series consists of light-colored, well-drained or somewhat excessively drained soils on bottom land along small streams and on alluvial fans. These soils developed in alluvial material that was derived from light-colored pumice sand mixed with other material. In the Prineville Area they occur along many drainageways, but their largest acreage is along the Dry and Crooked Rivers and in the Lone Pine area. Big sagebrush and annual and perennial grasses make up most of the plant cover.

The Metolius soils have a neutral, light brownish-gray sandy loam, loamy sand, or loam surface layer 6 to 10 inches thick. The subsoil is 8 to 14 inches of neutral or mildly alkaline, light brownish-gray to pale-brown sandy loam or loamy sand. Underlying the subsoil is a substratum of pale-brown to light brownish-gray sandy loam or loamy sand. This layer is 20 to 40 inches thick. It is mildly or moderately alkaline and, in places, is slightly calcareous. Gravel and sand generally occur at a depth of 6 feet or more.

These soils are used principally for irrigated crops, hay, and pasture.

Metolius sandy loam, 0 to 2 percent slopes (MsA).—This is the most extensive of the Metolius soils. The largest area occurs along the Dry River and is 150 to 1,300 feet wide, 3 miles or more long, and about 200 acres in size. In addition, there are smaller areas along McKay Creek, Johnson Creek, and other narrow drainageways. These areas generally are 150 to 500 feet wide and less than 1 mile long. Most of them occupy 15 to more than 50 acres, though a few are as small as 5 acres.

Representative profile:

0 to 18 inches, light brownish-gray sandy loam; soft in upper part, slightly hard in lower part; neutral.

18 to 60 inches +, sandy loam that is pale brown in the upper part and light brownish gray in the lower part; soft; mildly alkaline.

In areas along small intermittent drainageways north of Prineville, this soil contains less pumice than in other areas and has greenish chips and pebbles of tuff throughout the profile. The depth to gravel is 5 feet or more.

This soil is well drained. It has very slow runoff, is rapidly permeable, and is only slightly susceptible to erosion. Fertility and the moisture-holding capacity are moderate. Root growth is deep. Irrigating this soil and working it are very easy.

Except in the Dry River area, where frost is a hazard to potatoes, this soil is well suited to all crops grown in the Prineville Area. *Capability unit IIs-5*

Metolius sandy loam, 2 to 6 percent slopes (MsB).—Most of this soil is in tracts of 10 to 40 acres near Lone Pine and along the Dry River, the Crooked River, and intermittent drainageways north of Prineville. The soil is similar to Metolius sandy loam, 0 to 2 percent slopes. Areas in small intermittent drainageways, north of Prineville, contain less pumice than other areas and have greenish chips and pebbles of tuff throughout the profile. The depth to gravel or sand is 5 feet or more.

On this soil runoff is slow, permeability is rapid, the erosion hazard is moderate, and natural drainage is good. The moisture-holding capacity and fertility are moderate. Roots penetrate deeply. The soil is easily worked and can be irrigated with little difficulty.

Except in the Dry River area, where frost is a hazard to potatoes, this soil is well suited to all crops grown in the Area. *Capability unit IIe-2*

Metolius sandy loam, 6 to 12 percent slopes (MsC).—Most of this soil occurs in areas of 10 to 40 acres near Lone Pine and between Prineville and Combs Flat. The soil has a lower content of pumice and a higher content of basaltic material than Metolius sandy loam, 0 to 2 percent slopes. Sand or gravel is at a depth of 5 feet or more.

This soil is naturally well drained. It has rapid permeability and is easily penetrated by roots. Runoff is slow to medium, and the hazard of erosion is moderate to severe in irrigated fields. The moisture-holding capacity and fertility are moderate. The soil is difficult to irrigate and slightly difficult to work.

This soil is best suited to close-growing plants used for pasture. It is moderately well suited to alfalfa and small grain but, because of slope, is poorly suited to potatoes. *Capability unit IIIe-2*

Metolius sandy loam, 12 to 20 percent slopes (MsD).—This soil has a small total acreage, and most of it is in areas of 5 to 40 acres between Prineville and Combs Flat. It has a higher content of basaltic material and a lower content of pumice than Metolius sandy loam, 0 to 2 percent slopes. Its total thickness is 5 feet or more.

On this soil runoff is medium, permeability is rapid, and natural drainage is good. Fertility and the moisture-holding capacity are moderate. The soil is difficult to work but could be irrigated if water were available, though irrigation would be difficult and the erosion hazard would be severe.

None of this soil is irrigated. If water is provided, the soil can be used for crops, but it is poorly suited to potatoes and other row crops. Its suitability for hay and small grain varies from moderately good to poor. The best use is range or irrigated pasture. *Capability unit IVe-1*

Metolius loamy sand, 0 to 2 percent slopes (MoA).—This soil occurs mainly along the Crooked River and between Prineville and Combs Flat. It is loamy sand throughout, but in other respects it is like Metolius sandy loam, 0 to 2 percent slopes. The depth to underlying sand or gravel is 5 feet or more.

Natural drainage is somewhat excessive, and permeability is very rapid. The soil has very slow runoff and is only slightly erodible by water, but it is moderately susceptible to wind erosion. The moisture-holding capacity and fertility are moderate. Plant roots penetrate deeply. The soil is slightly difficult to irrigate but is very easy to work.

All crops grown locally are well suited to this soil. *Capability unit IIIs-1*

Metolius loamy sand, 2 to 6 percent slopes (MoB).—Most of this soil lies along the Crooked River, along intermittent drainageways north of Prineville, between Prineville and Combs Flat, and in the vicinity of Lone Pine. The soil commonly occupies areas of 10 to 40 acres.

Except for its loamy sand texture throughout, the profile of this soil is like that of Metolius sandy loam, 0 to 2 percent slopes. In areas along small intermittent drainageways north of Prineville, the soil has a lower content of pumice than in other areas and contains greenish chips and pebbles of tuff. The depth to a layer restricting the movement of roots and water is 5 feet or more.

This somewhat excessively drained soil has slow runoff and very rapid permeability. It is moderately susceptible to both water and wind erosion. Fertility and the moisture-holding capacity are moderate. The deep root zone is easily penetrated by roots. This soil is difficult to irrigate but is very easy to work.

All crops grown in the survey area are well suited to this soil. *Capability unit IIIs-1*

Metolius loamy sand, 6 to 12 percent slopes (MoC).—This soil generally occupies areas of 5 to 15 acres. It is loamy sand throughout, but otherwise it is similar to Metolius sandy loam, 0 to 2 percent slopes. A layer 4 to more than 5 feet below the surface restricts the movement of water and roots.

Natural drainage is somewhat excessive, permeability is very rapid, and runoff is slow to medium. Both wind and water erosion are severe hazards. The moisture-holding capacity and the fertility are low. Roots penetrate deeply. The soil is difficult to irrigate and slightly difficult to work.

This is a poor soil for potatoes. It is moderately well suited to small grain and alfalfa but is best suited to plants used for pasture. *Capability unit IVs-1*

Metolius loam, 0 to 2 percent slopes (MaA).—About half the acreage of this soil occurs in a single tract of more than 300 acres in the Lone Pine area. The soil also is extensive along the Dry and Crooked Rivers and in areas north and northwest of Prineville. These tracts cover from 10 to 100 acres.

This soil is 5 feet or more deep. It has a loam surface layer but in other respects is similar to Metolius sandy loam, 0 to 2 percent slopes. In parts of the Lone Pine area, it has a high water table that limits the growth of alfalfa.

The soil is naturally well drained. It has very slow runoff, is moderately permeable, and is only slightly susceptible to erosion. The moisture-holding capacity and fertility are moderate. The soil is easy to irrigate and very easy to work.

Most of this soil is under irrigation. Except along the Dry River, where frost is a hazard, the soil is well suited to potatoes. It is well suited to other row crops, small grain, and most plants grown for hay and pasture. Except in parts of Lone Pine that have a high water table, it is a good soil for alfalfa. *Capability unit IIs-5*

Ochoco Series

The Ochoco series consists of generally well-drained soils that have a light-colored surface layer and a medium-textured or moderately fine textured subsoil underlain by a hardpan. These soils developed in mixed gravelly material that had some pumice mixed into the upper layers. The vegetation consists mainly of big sagebrush and bluebunch wheatgrass, and there are a few scattered junipers.

Ochoco soils have a surface layer of neutral, light brownish-gray to grayish-brown loamy sand, sandy loam, gravelly sandy loam, loam, or gravelly loam. This layer is 3 to 8 inches thick. The subsurface layer is neutral, light brownish-gray to pale-brown loamy sand, sandy loam, fine sandy loam, gravelly sandy loam, loam, or gravelly loam. It is 3 to 10 inches thick.

The upper part of the subsoil consists of neutral, light brownish-gray to pale-brown fine sandy loam, loam, or sandy clay loam 3 to 8 inches thick. In many places this layer is gravelly. The lower part of the subsoil is 6 to 18 inches thick, generally is gravelly and mildly alkaline, and commonly is sandy clay loam.

At a depth of 20 to 36 inches, the subsoil overlies a weakly to strongly cemented hardpan that ranges from 4 to 15 inches in thickness. Roots generally form a mat on the hardpan because they cannot penetrate it, but the hardpan is partly softened by prolonged wetting.

The Ochoco soils are used mainly for irrigated crops, hay, and pasture.

Ochoco sandy loam, 0 to 2 percent slopes (OmA).—This soil has the largest acreage of the Ochoco soils. Most of it is on the terrace north of Prineville, though about 300 acres are in the vicinity of Lone Pine. Many areas range from 10 to 100 acres in size, but some are as small as 5 acres, and others cover as much as 400 acres. In most places this soil is adjacent to Prineville soils and other Ochoco soils.

Representative profile:

0 to 16 inches, light brownish-gray sandy loam; soft or slightly hard; neutral.

16 to 36 inches, pale-brown heavy fine sandy loam in the upper part, brown gravelly sandy clay loam in the lower part; slightly hard or hard; neutral or mildly alkaline.

36 to 46 inches, pale-brown, weakly to strongly cemented hardpan; moderately alkaline; calcareous.

46 to 60 inches, light-gray to very dark grayish-brown sand, sandy loam, or very gravelly loamy sand; weakly consolidated; moderately alkaline; calcareous.

The surface and subsurface layers are nongravelly, but in many places the subsoil is gravelly. The depth to hardpan ranges from 24 to 36 inches. Included in areas mapped as this soil are areas that have a fine sandy loam surface layer.

Runoff from this soil is slow, and the erosion hazard is only slight. Permeability is moderate or moderately slow in the subsoil, and root growth is moderately deep. The moisture-holding capacity and fertility are moderate. Irrigating this soil and working it are very easy.

This soil is well suited to potatoes, other row crops, small grain, alfalfa and other plants harvested for hay, and plants used for pasture (fig. 9). Most of the acreage is cultivated. *Capability unit IIs-3*

Ochoco sandy loam, seeped, 0 to 2 percent slopes (OoA).—This wet soil occupies only a few areas of 5 to 30 acres that lie below steeper Ochoco soils and receive seepage water from higher irrigated soils. Most of these areas are at the head of drainageways on the terrace north of Prineville.

The surface and subsurface layers of this soil are darker and, in places, are thicker than those of Ochoco sandy loam, 0 to 2 percent slopes. In many places the surface layer is slightly affected by alkali. The depth to hardpan ranges from 24 to 36 inches.

During the irrigation season, this soil contains free water in the subsoil. Runoff is very slow, and the erosion hazard is slight. Fertility and the moisture-holding capacity are moderate. The soil is very easy to irrigate, but it is very difficult to work because of excess water.

In most places this soil has a cover of wetland grasses and rushes. Unless drained, it is best suited to pasture and is only moderately well suited to small grain. It is a poor soil for potatoes and alfalfa. *Capability unit IIIw-1*

Ochoco sandy loam, 2 to 6 percent slopes (OmB).—Almost all of this soil lies below nearly level Ochoco and Prineville soils and above steeper Ochoco soils on the terrace north of Prineville and in the Lone Pine area. The soil occurs in many small tracts of 5 to 15 acres and in some larger ones, though only a few cover more than 80 acres.

This soil has a hardpan at a depth of 24 to 30 inches, but otherwise it is similar to Ochoco sandy loam, 0 to 2 percent slopes. The depth to hardpan is least on the ridgetops and is greatest in other areas.

On this soil runoff is slow, and the erosion hazard is moderate. The moisture-holding capacity and fertility are moderate. The soil is slightly difficult to irrigate but is very easy to work.

All crops grown in the Area are suited to this soil. Most of the acreage is cultivated. *Capability unit IIe-3*

Ochoco sandy loam, 6 to 12 percent slopes (OmC).—This soil generally occurs in areas of 5 to 25 acres. In many places it is in bands that lie above drainageways and are 150 to 500 feet wide and one-fourth to one-half mile long. Except for its 20- to 30-inch depth to hardpan, this soil is similar to Ochoco sandy loam, 0 to 2 percent slopes.

Water erosion is a severe hazard, and the soil is moderately erodible by wind. It has moderate moisture-holding capacity and fertility. Runoff is slow to medium. The soil is difficult to irrigate and slightly difficult to work.

This soil is best suited to close-growing pasture plants, and it is moderately well suited to alfalfa and small grain. It is poorly suited to potatoes because of slope. *Capability unit IIIe-3*

Ochoco gravelly sandy loam, 0 to 2 percent slopes (OhA).—Most of this soil is on the terrace north of Prineville, but part of it is on terraces along the Crooked River. The soil generally occupies areas of 5 to 25 acres. It occurs on slight ridges that adjoin areas of Ochoco sandy loam, 0 to 2 percent slopes, and along the edge of terrace escarpments that consist of steeper Ayres and Ochoco soils.

This soil is gravelly throughout and is 20 to 36 inches deep over hardpan. In other respects it is similar to Ochoco sandy loam, 0 to 2 percent slopes. Included in areas mapped as this soil are a few small areas that have a gravelly loam surface layer.

Runoft from this soil is very slow, and the erosion hazard is slight. The soil has moderate moisture-holding capacity and fertility. It is easy to irrigate and slightly difficult to work.

This soil is well suited to all crops grown in the survey area, but potatoes are somewhat difficult to produce because of gravel. *Capability unit IIs-3*

Ochoco gravelly sandy loam, 2 to 6 percent slopes (OhB).—This soil generally lies above terrace escarpments of steeper, gravelly Ayres and Ochoco soils. Most of the acreage is on the terrace north of Prineville, and the rest is on terraces along the Crooked River and in the Lone Pine area. The soil commonly is on short slopes and occurs in areas of 5 to 20 acres. In many places slopes are only 150 to 400 feet long. Except for its slope, its content of gravel throughout, and its 20- to 36-inch depth to hardpan,

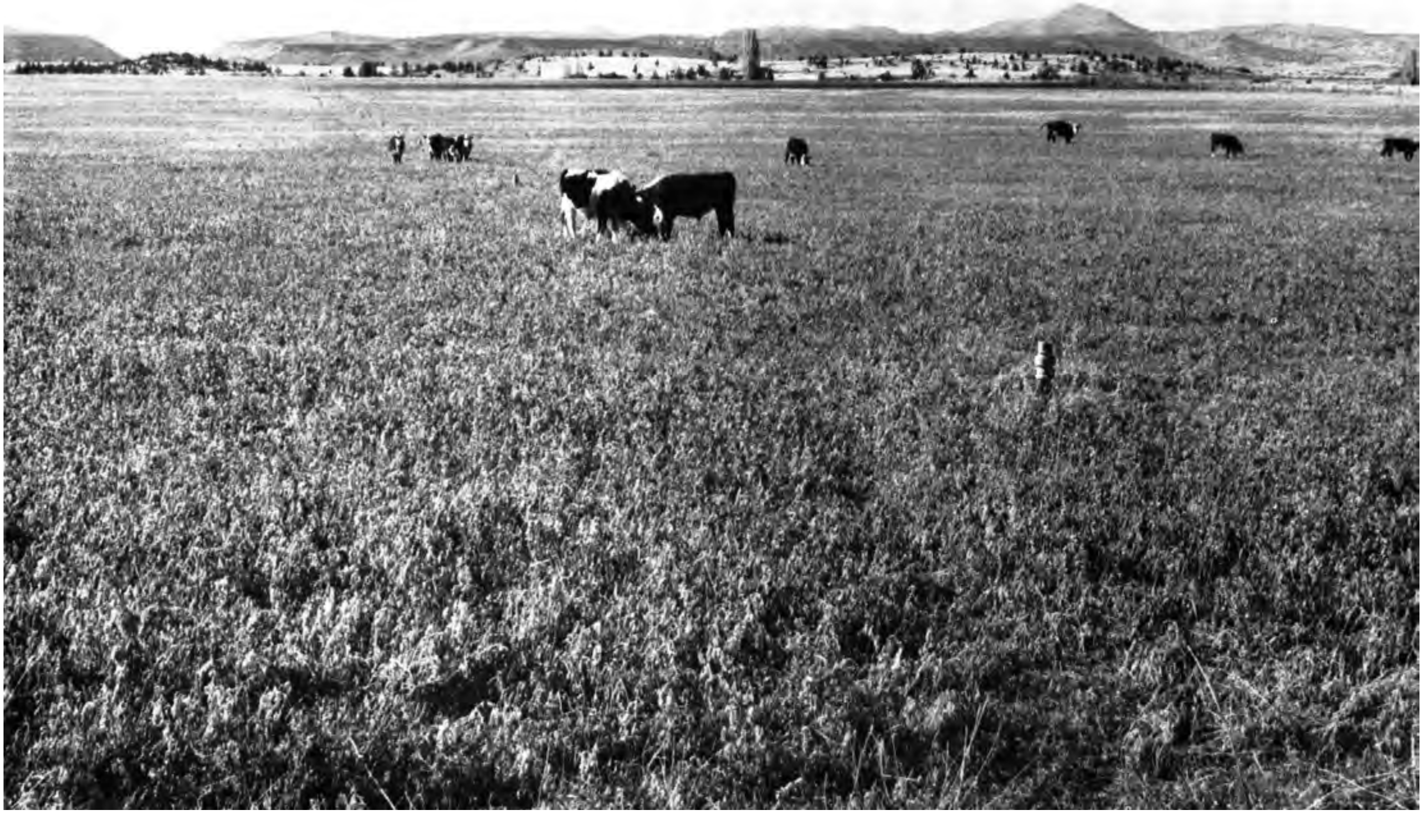

***Figure 9.*—Alfalfa irrigated from sprinklers on nearly level Ochoco and Prineville soils. Cattle are grazing late in fall.**

the soil is similar to Ochoco sandy loam, 0 to 2 percent slopes.

This soil has slow runoff and is moderately susceptible to erosion. It has moderate moisture-holding capacity and fertility. It can be worked and irrigated with little difficulty.

All crops grown locally are well suited to this soil, but potatoes are somewhat difficult to produce because of the gravel. *Capability unit IIe-3*

Ochoco loamy sand, 2 to 6 percent slopes (OdB).—Most of this soil is in areas of 40 to 100 acres that occur between 1 and 2 miles southeast of the community of Powell Butte. Nearby are areas of level and gently sloping Deschutes loamy sand, moderately deep over hardpan.

This soil has a 6- to 12-inch surface layer that is similar to the surface layer of Deschutes loamy sand. The subsoil, however, is like that of Ochoco gravelly sandy loam, 0 to 2 percent slopes, though in many places it is gravelly loam. The depth to hardpan ranges from 20 to 30 inches. Included in areas mapped as this soil are areas on slopes of less than 2 percent that make up about one-third of the total acreage.

On this soil runoff is slow, permeability is moderate, and the hazard of both wind and water erosion is moderate. Fertility and the moisture-holding capacity are low. Root growth is moderately deep. The soil is difficult to irrigate but is very easy to work.

About 20 percent of this soil is irrigated, and the rest is rangeland. All the acreage in range is above existing irrigation canals, but most of it is near them. This soil is well suited to all crops grown in the Area. *Capability unit IIIs-1*

Ochoco loam, 0 to 2 percent slopes (OcA).—This soil occurs in areas of 5 to 40 acres on terraces north of Prineville and in the vicinity of Lone Pine. In many places it adjoins other Ochoco soils, and in places it lies below Lamonta soils on alluvial fans.

This soil and Ochoco sandy loam, 0 to 2 percent slopes, differ in the texture of their surface and subsurface layers and subsoil, but in other respects the two soils are similar. This soil has surface and subsurface layers of loam and a subsoil of gravelly sandy clay loam or gravelly loam. The depth to hardpan ranges from 24 to 36 inches.

Runoff from this soil is very slow, and the erosion hazard is slight. The soil has moderate moisture-holding capacity and fertility. It is very easy to irrigate and to work.

All crops grown in the area are well suited to this soil. *Capability unit IIs-3*

Ochoco loam, 2 to 6 percent slopes (OcB).—This soil occupies only a few areas. These range from 5 to 40 acres in size, and most of them are on the terrace north of Prineville. In most places this soil is adjacent to other Ochoco soils and to Prineville soils.

This soil has surface and subsurface layers of loam and a subsoil of gravelly sandy clay loam or gravelly loam. Otherwise, it is similar to Ochoco sandy loam, 0 to 2 percent slopes. The depth to hardpan is 24 to 36 inches.

On this soil runoff is slow, and the erosion hazard is moderate. Fertility and the moisture-holding capacity are moderate. The soil is slightly difficult to irrigate but is very easy to work.

All crops grown locally are well suited to this soil. *Capability unit IIe-3*

Ochoco gravelly loam, 2 to 6 percent slopes (OgB).—This soil is north of Prineville and in the Lone Pine area. Generally, it occupies tracts of 5 to 30 acres that either lie at the head of drainageways or are just above terrace escarpments and below areas of Ochoco sandy loam, 0 to 2 percent slopes.

Except for its gravelly loam surface and subsurface layers and its gravelly sandy clay loam or gravelly loam subsoil, this soil is similar to Ochoco sandy loam, 0 to 2 percent slopes. The depth to hardpan is 24 to 36 inches.

This soil has slow runoff but is moderately susceptible to erosion. It is moderate in moisture-holding capacity and in fertility. Irrigating this soil and working it are slightly difficult.

All crops grown in the area are well suited to this soil, but potatoes are fairly difficult to produce because the soil is gravelly. *Capability unit IIe-3*

Ontko Series

Soils of the Ontko series are dark colored and poorly or very poorly drained. They occur on bottom land along Mill and Ochoco Creeks north and east of Ochoco Reservoir. These soils developed in mixed alluvium that contained pumice. Their native cover was grasses, sedges, and a small amount of clover. They are subject to frequent flooding, and their water table fluctuates between the depths of 18 and 36 inches during much of the year.

Ontko soils have a surface layer of neutral clay loam or clay that is 4 to 8 inches thick and is black or very dark gray when moist. The subsurface layer is similar to the surface layer but is mottled.

The subsoil is neutral clay loam, gravelly clay loam, or clay 8 to 14 inches thick. This layer is very dark gray or very dark grayish brown when moist. The substratum consists of sand, silt, clay, and gravel in variable amounts. This material does not restrict the growth of roots. Generally, the content of pumice in Ontko soils increases from the surface layer to the substratum.

These soils are commonly used for irrigated hay and pasture, and some areas are kept in native cover.

Ontko clay loam and clay (Ot).—This mapping unit commonly occupies areas of 5 to 25 acres and is in nearly level positions that are slightly above areas of Ontko clay loam, ponded.

Representative profile of Ontko clay loam:

0 to 7 inches, clay loam, black when moist; firm and sticky; neutral.

7 to 22 inches, very dark gray clay loam mottled with dark reddish brown and dark olive; firm and sticky; neutral.

22 to 43 inches +, very dark grayish-brown, mottled, stratified loamy coarse sand to silty clay loam; slightly acid to mildly alkaline.

Included in areas mapped as Ontko clay loam and clay are a few small areas that have a loam surface layer. In addition, about 15 percent of the total acreage is gravelly in the surface layer and subsoil.

Runoff is very slow, and there is little or no erosion hazard. Permeability is moderately slow or slow. Fertility is high, and the moisture-holding capacity is very high. Roots penetrate deeply. Irrigation is only slightly difficult, but tillage and harvesting are difficult or very difficult.

These soils are used for hay crops and for grazing in summer. Unless drained, they are poorly suited to most crops grown in the Area. They are best suited to irrigated pasture and to hay plants other than alfalfa. *Capability unit IVw-2*

Ontko clay loam, ponded (Op).—This very poorly drained soil generally occupies low, level areas in depressions below Ontko clay loam, and it is similar to that soil. Most areas range from 5 to 25 acres in size. Included in areas mapped as this soil are several small areas in which the upper 16- to 24-inch layer is clay.

Water stands on this soil during much of the year, and there is little or no erosion hazard. In most places the soil is so wet that hay crops cannot be mowed, even with a team of horses. The main plants on it are sedges and rushes. *Capability unit Vw-1*

Polly Series

In the Polly series are well-drained soils on alluvial fans in and near the Ochoco Mountains. These soils have a moderately dark colored surface layer and a reddish-brown or brown clay loam subsoil. They developed in alluvium that was derived chiefly from tuff and basalt. The plant cover consisted mainly of big sagebrush, bitterbrush, Idaho fescue, bluebunch wheatgrass, and juniper.

The surface layer of Polly soils is neutral, dark-gray or grayish-brown sandy loam, loam, gravelly loam, or stony loam. It is 5 to 12 inches thick.

The upper part of the subsoil is neutral or mildly alkaline, grayish-brown to reddish-brown loam or clay loam 4 to 10 inches thick. In places this layer contains gravel or stones. The lower part of the subsoil consists of hard, reddish-brown clay loam that is 12 to 18 inches thick, is mildly or moderately alkaline and, in many places, is slightly or moderately calcareous.

The substratum is moderately alkaline, brown, pale-brown, or yellowish-red clay loam, loam, or fine sandy loam. In many places this layer contains gravel, and in many places it is calcareous. It does not hinder the movement of water or the growth of roots.

The Polly soils are used principally for dryfarmed grain and as rangeland. A few acres are irrigated and used for crops, hay, and pasture.

Polly gravelly loam, 6 to 12 percent slopes (PgC).—In many places this soil is below Gem very stony loam, 6 to 40 percent slopes, and Gem-Searles stony loams, 6 to 40 percent slopes, and is just above Veazie, Ontko, or Courtrock soils. Most areas of this soil range from 5 to 35 acres in size. The largest one covers about 120 acres and is in the vicinity of Lone Pine.

Representative profile:

0 to 6 inches, dark-gray gravelly loam; slightly hard; neutral.
6 to 27 inches, grayish-brown to reddish-brown clay loam that is gravelly in the upper part; hard; neutral to moderately alkaline; slightly or moderately calcareous in the lower part.
27 to 72 inches, yellowish-red to brown clay loam; hard; moderately alkaline; slightly to strongly calcareous.

The coarse fragments of gravel generally are basalt or tuff, but in some places they are rhyolite and andesite. Included in areas mapped as this soil are several areas of 10 to 15 acres that have a cobbly sandy loam surface layer.

This soil has slow to medium runoff and moderately slow permeability. In dryfarmed areas the erosion hazard is moderate, but in irrigated fields it is severe. Roots penetrate deeply. Although the soil has high moisture-holding capacity and fertility, it is difficult to irrigate and to work.

Almost none of this soil is irrigated. About one-third of it has been dryfarmed to small grain for hay or grain, chiefly in the areas of Ochoco Creek and Johnson Creek. The soil is moderately well suited to dryland grain. Under irrigation, it is poorly suited to potatoes but is moderately well suited to small grain and to pasture plants. *Capability unit IIIe-3*

Polly gravelly loam, 0 to 6 percent slopes (PgB).—This soil lies on alluvial fans. It generally occupies areas of 5 to 25 acres that are just above soils on the flood plain and are below areas of steeper Polly soils or of Gem, Searles, and other soils on uplands. Most of the acreage is on slopes of 2 to 6 percent.

This soil is similar to Polly gravelly loam, 6 to 12 percent slopes, but its surface layer ranges from gravelly loam to gravelly sandy loam. In areas where the coarser texture occurs, the soil contains more pumice than in other areas. The pebbles and cobbles generally are basalt, but in some places they are rhyolite or andesite.

On this soil runoff is slow or very slow. The erosion hazard is only slight in dryland areas but is moderate in irrigated fields. Moisture-holding capacity and fertility are moderate. The soil is slightly difficult to irrigate and to work.

About 20 percent of the acreage is irrigated, and most of the rest is dryfarmed. The soil is poorly suited to potatoes but is well suited to other irrigated crops and to dryland crops grown in the Area. *Capability unit IIe-4*

Polly stony loam, 6 to 20 percent slopes (PlD).—Most of this soil is in tracts of 10 to 25 acres and occurs in the areas of Johnson Creek, McKay Creek, and Lone Pine. In many places the soil lies just below areas of Gem or Searles soils. About three-fourths of the acreage is on slopes of 12 to 20 percent.

This soil is similar to Polly gravelly loam, 6 to 12 percent slopes, but its surface layer and subsoil are stony instead of gravelly. In most places the stones are basalt and tuff, but in a few places they are rhyolite or andesite.

This soil has slow to medium runoff and is moderately susceptible to erosion. It has moderate moisture-holding capacity and fertility. The soil is very difficult to work and is not suitable for irrigation.

About three-fourths of this soil is rangeland, and the rest is dryfarmed. The soil is best suited to range. *Capability unit VIe-2*

Polly loam, 0 to 6 percent slopes (PaB).—This soil generally lies at the foot of moderately steep or steep Gem and Searles soils. Most of it is in the areas of Ochoco Creek, Johnson Creek, and Lone Pine, and about three-fourths of it is on slopes of 2 to 6 percent. More than half the areas range from 10 to 25 acres in size. This soil is similar to Polly gravelly loam, 6 to 12 percent slopes, but it is gently sloping and its surface layer and upper subsoil are not gravelly.

On this soil runoff is slow or very slow. The erosion hazard is slight in dryfarmed areas and moderate in irrigated areas. Fertility and the moisture-holding capacity are high. The soil is easily worked and can be irrigated with little difficulty.

About 25 percent of this soil is used for range, and the rest is cultivated, mainly to dryland crops. Although the soil is poorly suited to potatoes, it is well suited to all other crops grown in the survey area. *Capability unit IIe-4*

Polly loam, 6 to 12 percent slopes (PaC).—This soil occurs mainly in the areas of McKay Creek, Ochoco Creek, and Mill Creek. In most places it is below steep or moderately steep Gem soils and just above Veazie soils and other soils on alluvial flood plains. Most areas cover from 5 to 25 acres.

Except for its nongravelly surface layer and upper subsoil, this soil is similar to Polly gravelly loam, 6 to 12 percent slopes. Included in areas mapped as this soil are areas that have a clay loam surface layer and make up about 30 percent of the total acreage.

This soil has slow to medium runoff. It is moderately susceptible to erosion in dryland areas but is highly erodible if irrigated and not protected. The moisture-holding capacity and fertility are high. The soil is difficult to irrigate and is slightly difficult to work.

About half of this soil is cultivated, principally to dryland crops, and half is used for range. The soil is not suited to potatoes, but it is moderately well suited to other crops grown in the Area. *Capability unit IIIe-3*

Polly sandy loam, 2 to 6 percent slopes (PhB).—This inextensive soil occurs in the Ochoco Creek area, along small streams north of Prineville, and on the high plateau between Prineville and Combs Flat. It occupies areas 5 to 35 acres in size.

The surface layer of this soil is neutral, porous, grayish-brown sandy loam 6 to 8 inches thick. It contains a moderate amount of pumice and a few pebbles. The subsurface layer is neutral, grayish-brown sandy loam or light loam that contains a few pebbles. This layer extends to a depth of about 15 inches. The subsoil is brown or reddish-brown clay loam. At a depth of 30 inches, it is underlain by mixed calcareous gravel, sand, or loamy material that does not prevent the growth of roots or the movement of water.

Although this soil has slow runoff, it is moderately susceptible to erosion if irrigated. The moisture-holding capacity and fertility are moderate to high. The soil is slightly difficult to irrigate but is very easy to work.

Most of this soil is under cultivation. Some of it is dryfarmed, and some is irrigated. The soil is well suited to all crops grown locally except potatoes. *Capability unit IIe-4*

Polly sandy loam, thick surface, 2 to 6 percent slopes (PkB).—This inextensive soil occurs in the areas of Mill Creek and Ochoco Creek, along small drainageways north of Prineville, and on the high plateau between Prineville and Combs Flat. The largest area covers about 60 acres and lies on the high plateau southeast of Prineville. Other areas range from 5 to 30 acres in size.

The surface and subsurface layers of this soil are much thicker than those of Polly sandy loam, 2 to 6 percent slopes. These layers have a total thickness of 2 feet or more, and they contain a moderate amount of pumice sand.

Although this soil has slow runoff, it is moderately susceptible to erosion in irrigated fields. It has moderate to high moisture-holding capacity and fertility. The soil is slightly difficult to irrigate but is very easy to work.

Except on the high plateau southeast of Prineville, some areas of this soil are irrigated, and others are dryfarmed. The soil is well suited to all crops grown locally except potatoes. Figure 10 shows an area of this soil in alfalfa that has been heavily grazed. *Capability unit IIe-4*

Polly sandy loam, thick surface, 6 to 12 percent slopes (PkC).—This soil occupies tracts of 5 to 30 acres and is mainly in the areas of Johnson Creek, Mill Creek, and Ochoco Creek. It is similar to Polly sandy loam, 2 to 6 percent slopes, but has thicker surface and subsurface layers. These layers are at least 2 feet thick, and they have a moderate content of pumice sand.

Runoff is slow to medium, but severe erosion is likely to occur in irrigated fields if the soil is not protected. The moisture-holding capacity and fertility are moderate to high. The soil is difficult to irrigate and slightly difficult to work.

About half of this soil is used as range, and most of the rest is dryfarmed. Although the soil is poorly suited to potatoes and other row crops, it is moderately well or well suited to all other crops grown in the Area. *Capability unit IIIe-3*

Powder Series

The Powder series consists of light-colored, well drained or moderately well drained soils on low, nearly level benches along the Crooked River and Ochoco Creek. These soils developed in mixed alluvium derived mainly from basalt. Giant wildrye and other grasses make up the plant cover.

The Powder soils have a loam, gravelly loam, silt loam, or sandy loam surface layer 5 to 10 inches thick. This layer is neutral and is light brownish gray to grayish brown. The subsoil is similar in color; it consists of porous, mildly alkaline loam or silt loam that is 6 to 15 inches thick.

The upper substratum is grayish-brown to brown silt loam, loam, or fine sandy loam. This layer is moderately alkaline and calcareous. The lower substratum occurs at a depth of 20 to more than 72 inches and is made up of stratified material ranging from silt loam to gravel and sand.

The Powder soils are used for irrigated crops, hay, and pasture.

Powder loam (Pm).—This nearly level soil occurs on the flood plain and is generally slightly higher than Powder sandy loam. It commonly occupies areas of 20 to 50 acres, though a few areas are as small as 5 acres. The largest area covers several hundred acres and is between Prineville and the Ochoco Reservoir. In places where this soil has uneven relief because of old stream channels, it is frequently flooded for short periods in spring.

Representative profile:

0 to 6 inches, grayish-brown loam; weak, platy structure; soft or slightly hard; neutral.
6 to 25 inches, grayish-brown loam; soft or slightly hard; mildly or moderately alkaline; calcareous in the lower part.
25 to 80 inches, grayish-brown to gray, stratified silt loam to fine sandy loam; moderately alkaline; calcareous.

The depth to gravel commonly is more than 6 feet.

This soil is well drained. It has very slow runoff and moderate permeability, and it is only slightly susceptible to erosion. The moisture-holding capacity and fertility are high. Roots penetrate deeply. The soil is very easy to irrigate and to work.

This soil is well suited to all crops grown locally, and nearly all of it is irrigated. *Capability unit IIc-1*

Powder gravelly loam (Pr).—This soil lies in narrow bands along streams. It is closer to the Crooked River and other major streams and to old, abandoned stream channels than are the other medium-textured Powder soils. As a consequence, it is frequently washed or channeled during floods in spring. Sand and gravel occur at a depth of 24 to 36 inches. Included in areas mapped as this soil are small areas that have a surface layer of gravelly fine sandy loam.

This well-drained soil has very slow runoff and moderately rapid permeability. Its moisture-holding capacity and fertility are moderate. The soil is easy or very easy to irrigate but is slightly difficult to work.

This soil is moderately well suited to small grain, to alfalfa and other plants harvested for hay, and to plants used for pasture. It is poorly suited to potatoes. *Capability unit IIe-6*

Powder silt loam (Pt).—This nearly level soil occupies areas that generally range from 10 to 75 acres in size and commonly are 400 to 800 feet wide and 1,000 to 5,000 feet long. In many places it is slightly above areas of Boyce soils and is below most other Powder soils.

The surface layer of this soil is silt loam or loam. The depth to sand and gravel ranges from 36 to more than 60 inches. In a few places the soil is noncalcareous throughout. In some places the subsoil and substratum are mottled. Some areas are slightly affected by alkali, and some areas near the Crooked River are cut by old stream channels.

This soil is well drained or moderately well drained. Although it is subject to flooding in spring, there is little or no erosion hazard. Runoff is very slow, permeability is moderate, and the moisture-holding capacity and fertility are high or very high. The soil is very easy to irrigate and is easy or slightly difficult to work.

Wheat, barley, alfalfa, other hay plants, and pasture plants are well suited to this soil. Potatoes are poorly suited. *Capability unit IIe-6*

Powder silt loam, over gravel (Pu).—This soil is in areas of 10 to 25 acres that lie mainly along the Crooked River west of Prineville. Most of these areas are adjacent to the river, and many of them are near areas of Powder gravelly loam and Riverwash.

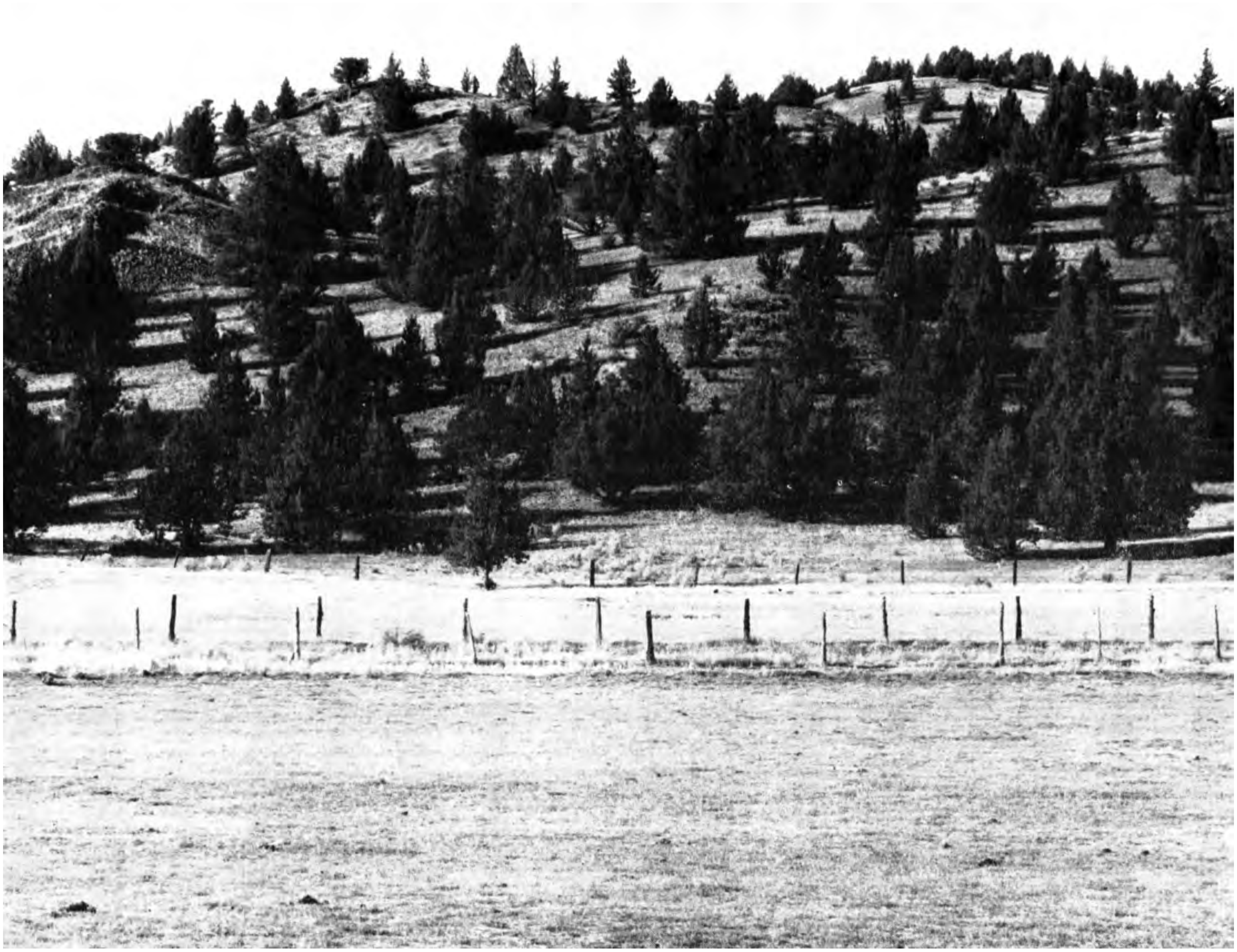

***Figure 10.*—In the foreground is heavily grazed alfalfa on Polly sandy loam, thick surface, 2 to 6 percent slopes. Trees in the background are junipers.**

The surface layer of this soil is silt loam or loam. The underlying sand and gravel are within 20 to 24 inches of the surface. In some places the soil is noncalcareous throughout all horizons. In many places it is cut by old stream channels and is subject to frequent flooding in spring.

This soil is well drained or moderately well drained and has moderate permeability. Because runoff is very slow, there is little or no erosion hazard. The soil is slightly difficult to irrigate and is slightly difficult or difficult to work. Its moisture-holding capacity and fertility are moderate.

This soil is poorly suited to potatoes but is moderately well suited to all other crops grown in the survey area. *Capability unit IIe–6*

Powder sandy loam (Ps).—This nearly level soil commonly occurs on flood plains next to streams. Most areas range from 10 to 40 acres in size, but several are larger than 100 acres. The soil is flooded in spring more frequently than Powder loam, and it has an uneven surface in places where it is crossed by old stream channels.

This soil is moderately coarse textured in the upper 12 to 15 inches, but otherwise it is similar to Powder loam. In most places the depth to gravel is more than 6 feet.

This soil is well drained and is moderately permeable. The moisture-holding capacity and fertility are high. Runoff is very slow. The soil is very easy to irrigate and to work. It is well suited to crops commonly grown in the Area, and nearly all of it is irrigated. *Capability unit IIc–1*

Powder fine sandy loam, coarse variant (Pn).—This soil is mainly along the Crooked River and its tributaries northwest of Prineville. In most places it lies between the river and areas of Powder silt loam. The soil is fine sandy loam or very fine sandy loam from the surface to the underlying gravel and sand, which occur at a depth of 24 to 48 inches. Small areas next to slightly lower, wet soils are affected by alkali.

This soil commonly is flooded in spring. It is well drained and has moderate moisture-holding capacity. Permeability is moderately rapid, and runoff is very slow. The soil is moderately fertile, is very easy to irrigate and to work, and can be worked sooner in spring than Powder silt loam.

This soil is well suited to small grain, alfalfa and other hay crops, and plants used for pasture. It is poorly suited to potatoes. *Capability unit IIe–6*

Powder fine sandy loam, over gravel, coarse variant (Po).—This soil is in areas on bottom land where the Crooked River has deposited fine sandy loam over gravel. The depth to gravel and sand is 20 to 24 inches. In many places the soil is channeled, for it is frequently flooded in spring.

This soil is well drained or moderately well drained. It has moderately rapid permeability, and its moisture-holding capacity and fertility are low. Runoff is very slow. The soil is easy to irrigate and very easy to work. It is poorly suited to potatoes but is well suited to small grain, to alfalfa and other hay crops, and to plants used for pasture. *Capability unit IIe–6*

Prineville Series

In the Prineville series are well-drained soils that have light-colored surface and subsurface layers over a moderately coarse textured or coarse textured subsoil that is underlain by a weakly to strongly cemented hardpan. These soils are on the terrace north of Prineville and in the Lone Pine area. They formed in mixed gravel, sand, and silt that were deposited by water. Big sagebrush and bluebunch wheatgrass make up most of the plant cover, and there are a few scattered junipers.

The Prineville soils have a surface layer of soft, neutral, light brownish-gray sandy loam or gravelly sandy loam 5 to 15 inches thick. Their subsurface layer is light brownish-gray fine sandy loam 4 to 12 inches thick. It is soft, gravelly or nongravelly, and neutral or mildly alkaline.

The subsoil is 3 to 14 inches of light brownish-gray fine sandy loam to loamy sand. This layer is gravelly or nongravelly and neutral to moderately alkaline. In many places it is underlain by a parent substratum of pale-brown, slightly calcareous gravelly sandy loam 10 to 30 inches thick.

Below the subsoil or the substratum is a hardpan consisting of massive, or structureless, gravelly or sandy material that is weakly to strongly cemented with lime and silica and is 4 to 30 inches thick. Although it tends to soften if wet for a long time, the hardpan is penetrated by only a few roots and commonly is covered by a mat of them. In many places the depth to the pan ranges from 20 to 36 inches.

The Prineville soils are used principally for irrigated crops, hay, and pasture.

Prineville sandy loam, 0 to 2 percent slopes (PvA).—This soil makes up about one-third the acreage of all Prineville soils in the Area. About three-fourths of it is on the terrace north of Prineville, and most of the rest is in the vicinity of Lone Pine. The soil generally occurs in areas of 5 to 40 acres, though a few areas are as large as 75 to more than 100 acres. In many places this soil adjoins areas of Ochoco soils and other Prineville soils.

Representative profile:

0 to 9 inches, light brownish-gray sandy loam; soft; neutral.
9 to 20 inches, light brownish-gray fine sandy loam; soft or slightly hard; neutral to moderately alkaline.
20 to 47 inches, pale-brown very fine sandy loam; lenses of weakly cemented hardpan; slightly calcareous; strongly alkaline.
47 to 60 inches, light brownish-gray gravelly loamy fine sand; soft; strongly calcareous.

In most places the subsoil is fine sandy loam. The hardpan is at a depth ranging from 20 to 42 inches and is weakly to strongly cemented. A few small areas are wet because they receive water that moves laterally from irrigated fields nearby. In some areas mapped as this soil and included with it, the surface layer is fine sandy loam, and in a few small areas it is loam or loamy sand.

On this soil runoff is very slow, and the erosion hazard is only slight. Permeability is moderately rapid above the hardpan and is slow in it. Root growth is moderately deep. The soil has low to moderate fertility and moisture-holding capacity. It is very easy to irrigate and to work.

This soil is well suited to all crops grown in the Area. Nearly all the acreage is cultivated. *Capability unit IIs–1*

Prineville sandy loam, 2 to 6 percent slopes (PvB).—This soil is mainly in areas of 5 to 30 acres. In many places it lies near drainageways or above terrace escarpments and below areas of nearly level Prineville and Ochoco soils. About two-thirds of the acreage is on terraces north of Prineville, and the rest is in the vicinity of Lone Pine.

Except for its stronger slopes, this soil is similar to Prineville sandy loam, 0 to 2 percent slopes. The subsoil ranges from fine sandy loam to loamy sand. The depth to hardpan ranges from 20 to 42 inches. Because irrigation water moves laterally from adjacent fields, a few small areas of this soil are wet. Included in areas mapped as this soil are areas that have a fine sandy loam surface layer and a few areas that have a loamy sand surface layer.

Although runoff is slow, the erosion hazard is moderate. The moisture-holding capacity and fertility are low to moderate. The soil is easily worked and can be irrigated with little difficulty.

All crops grown locally are well suited to this soil. Most of the acreage is cultivated. *Capability unit IIe–1*

Prineville sandy loam, 6 to 12 percent slopes (PvC).—This soil occurs along the edge of terraces and along dry drainageways that are cut into the terraces. Generally, it is in areas of 5 to 10 acres on short slopes.

The profile of this soil is similar to that of Prineville sandy loam, 0 to 2 percent slopes. The depth to hardpan ranges from 20 to 42 inches. Included in areas mapped as this soil are areas with a fine sandy loam surface layer.

Although runoff is slow to medium, this soil is highly erodible if it is irrigated and not protected. It is difficult to irrigate and slightly difficult to work. The moisture-holding capacity and fertility are low to moderate. The soil is poorly suited to potatoes and other row crops, but it is well suited to other crops grown in the survey area. *Capability unit IIIe–1*

Prineville sandy loam, thick surface, 0 to 2 percent slopes (PwA).—This soil is mainly in areas above the terrace north of Prineville. It commonly occurs below the steeper Prineville sandy loams that have a thick surface layer.

The upper layers of this soil are thicker than those of Prineville sandy loam, 0 to 2 percent slopes, and in many places they are slightly coarser textured because they contain more pumice. The surface layer is 10 to 15 inches thick. Hardpan occurs at a depth ranging from 42 to 60 inches. Included in areas mapped as this soil are several small areas that have a surface layer of loamy sand.

On this soil runoff is very slow, and the hazard of water erosion is only slight, but wind erosion is a moderate hazard. The moisture-holding capacity and fertility are moderate. Roots penetrate deeply. The soil is very easy to irrigate and to work.

This soil is well suited to all crops grown in the Area. It is particularly desirable for potatoes. *Capability unit IIs-2*

Prineville sandy loam, thick surface, 2 to 6 percent slopes (PwB).—This soil is in larger areas than other Prineville soils. Some areas cover 40 acres or more. Most of the acreage is above the terrace north of Prineville, but some of it occurs in and near Lone Pine.

Because the upper layers of this soil contain more pumice than those of Prineville sandy loam, 0 to 2 percent slopes, they are slightly coarser textured. The depth to hardpan ranges from 42 to 60 inches. In about one-third of the acreage mapped as this soil and included with it, the upper layers consist of loamy sand 24 inches thick.

Although runoff is slow, there is a moderate hazard of water erosion in irrigated areas. Because of the sandy loam surface layer, the soil is moderately susceptible to wind erosion. The moisture-holding capacity and fertility are moderate. Irrigating the soil is slightly difficult, but working it is very easy.

This soil is well suited to all crops grown in the survey area. It is a particularly good soil for potatoes. *Capability unit IIe-2*

Prineville sandy loam, thick surface, 6 to 12 percent slopes (PwC).—This soil is in small areas of 5 to 10 acres and in larger areas of 40 acres or more. In many places it lies below areas of Slayton and Searles soils and above areas of nearly level and gently sloping Prineville and Ochoco soils.

This soil has more pumice in the surface layer than Prineville sandy loam, 0 to 2 percent slopes, but in other respects the two soils are similar. The depth to hardpan ranges from 42 to 60 inches.

This soil has slow to medium runoff but, if it is irrigated, is subject to severe erosion by water. Wind erosion is a moderate hazard. The soil has moderate moisture-holding capacity and fertility. It is difficult to irrigate because of slope, and it is slightly difficult to work.

Close-growing plants used for pasture are best suited to this soil. Alfalfa and small grain are moderately well suited, but potatoes are poorly suited. *Capability unit IIIe-2*

Prineville gravelly sandy loam, 2 to 6 percent slopes (PxB).—This soil is inextensive and occupies only a few areas, most of which range from 5 to 15 acres in size. It occurs near the edge of the terrace north of Prineville, below nearly level areas of Prineville and Ochoco soils and above steeper areas of those soils.

This soil is gravelly throughout and sloping, but otherwise it is similar to Prineville sandy loam, 0 to 2 percent slopes. The depth to hardpan is 20 to 36 inches. Included in areas mapped as this soil are areas that have a surface layer of gravelly fine sandy loam.

Under irrigation, this soil is moderately susceptible to erosion, though runoff is slow. Moisture-holding capacity and fertility are low. Roots penetrate to a moderate depth. The soil is slightly difficult to irrigate and to work.

This soil is well suited to all crops grown in the Area, but gravel hinders the growth and harvesting of potatoes. *Capability unit IIe-1*

Prineville gravelly sandy loam, 6 to 20 percent slopes (PxD).—This soil occurs in areas of 10 to 40 acres that are mainly on terrace escarpments. In most places slopes are only 150 to 400 feet long. In a few places they are steeper than 20 percent.

This soil is similar to Prineville sandy loam, 0 to 2 percent slopes, but it is gravelly throughout and is 20 to 24 inches deep to hardpan. Included in areas mapped as this soil are small areas of Ochoco soils.

Although runoff is slow to medium, this soil is subject to moderate or severe erosion if it is irrigated. Its moisture-holding capacity and fertility are low. It is very difficult to irrigate and difficult to work.

This Prineville soil is best suited to range grasses or to plants used for irrigated pasture. It is poorly suited to most crops grown locally. Most of the acreage is not cultivated. *Capability unit IVe-1*

Redmond Series

The Redmond series consists of light-colored, well-drained soils that occur on the upland plateau in the western part of the Area from the Prineville Airport to the Deschutes County line. These soils developed mainly from pumice sand and are in small basins surrounded by higher, stony or rocky areas. The original plant cover was mostly sagebrush, bluebunch wheatgrass, and scattered juniper. The light-colored surface and subsurface layers are over a finer textured subsoil that is underlain by basalt bedrock or other material. In most places a layer of lime has accumulated on top of the bedrock.

The Redmond soils have a surface layer of grayish-brown, pumiceous sandy loam or loam 3 to 8 inches thick. This layer is nonstony to very stony, soft, and neutral. The subsurface layer is 3 to 10 inches thick and slightly hard, but in color, texture, and reaction it is similar to the surface layer.

The upper subsoil, 0 to 8 inches thick, consists of brown heavy sandy loam or loam that is nonstony to very stony and is neutral or mildly alkaline. The lower subsoil is 4 to 10 inches of brown loam, sandy clay loam or clay loam. It is nonstony to very stony and is neutral or mildly alkaline.

The substratum is pale-brown to light brownish-gray loam or heavy sandy loam 5 to 12 inches thick. This material is mildly or moderately alkaline, is calcareous in the lowest few inches, and occurs on basalt or other bedrock. The depth to bedrock ranges from 16 to 36 inches.

The Redmond soils are mainly in range.

Redmond sandy loam, 0 to 2 percent slopes (RmA).—This soil accounts for about 40 percent of all the acreage of the Redmond soils. It commonly occupies concave areas below the Deschutes, Bakeoven, and other Redmond soils, and in places it is above Swartz silt loam, which occurs in basins that have no outlet. The total acreage of this Redmond soil is made up of many individual areas.

These areas ordinarily range from less than 5 to 40 acres in size, but a few are larger than 100 acres.

Representative profile:

0 to 11 inches, grayish-brown sandy loam; soft or slightly hard; neutral.
11 to 25 inches, brown heavy sandy loam to sandy clay loam; soft or slightly hard; neutral or mildly alkaline.
25 to 33 inches, brown to light brownish-gray loam; hard; mildly or moderately alkaline; calcareous in the lower few inches.
33 inches +, basalt bedrock.

The depth to bedrock ranges from 20 to 36 inches. Included in areas mapped as this soil are areas that have a fine sandy loam surface layer and a few small areas that have a loamy sand surface layer.

This soil has very slow runoff and is only slightly susceptible to erosion, even in irrigated areas. It is moderate in permeability, moisture-holding capacity, and fertility. Root growth is moderately deep. The soil is very easy to irrigate and to work.

This soil is well suited to all crops grown locally. Irrigation water is not available, however, and many areas are in range, chiefly those between the Dry River and the Deschutes County line. *Capability unit IIs-3*

Redmond sandy loam, 2 to 6 percent slopes (RmB).—This gently sloping soil occurs in areas that generally are just above nearly level Redmond soils and, in places, are above Swartz silt loam. Many of these areas range from 10 to 20 acres in size.

This soil is similar to Redmond sandy loam, 0 to 2 percent slopes. The depth to bedrock is 20 to 36 inches. Included in areas mapped as this soil are areas that have a loam surface layer and make up about 15 percent of the total acreage.

Erosion is a moderate hazard in irrigated fields, though runoff is slow. The soil has moderate moisture-holding capacity and fertility. It is slightly difficult to irrigate but very easy to work.

This soil is well suited to all crops grown in the Area. Because no water is available, however, most of the acreage is not irrigated. *Capability unit IIe-3*

Redmond stony sandy loam, 0 to 6 percent slopes (RoB).—This soil makes up about 20 percent of the total acreage of Redmond soils. In most places it is below Bakeoven soils and is adjacent to Deschutes soils and other Redmond soils. It commonly occurs in tracts of 10 to 30 acres.

Except for its stony surface and subsurface layers, this soil is similar to Redmond sandy loam, 0 to 2 percent slopes. The depth to bedrock ranges from 20 to 36 inches. Included in areas mapped as this soil are areas that have stony loamy sand surface and subsurface layers and that make up about 10 percent of the total acreage. Also included are areas that have a stony fine sandy loam surface layer.

This soil has slow or very slow runoff, but it is slightly or moderately susceptible to erosion in irrigated fields. Fertility and the moisture-holding capacity are moderate. Irrigation is slightly difficult or difficult, but tillage and harvesting are very difficult. In some areas not under cultivation, the stones can be removed at reasonable expense.

This soil is poorly suited to most crops grown in the Area. If irrigated, it is best suited to plants used for pasture. *Capability unit IVs-2*

Redmond very stony sandy loam, 6 to 12 percent slopes (RrC).—In most places this soil lies below Bakeoven soils or adjoins Redmond stony sandy loam, 0 to 6 percent slopes. It commonly occurs in areas of 15 to 30 acres.

This soil is strongly sloping, is very stony throughout, and is only 16 to 30 inches deep over bedrock, but in other respects it is similar to Redmond sandy loam, 0 to 2 percent slopes. Included in areas mapped as this soil are areas that have a very stony loam surface layer.

On this soil runoff is slow to medium, and the erosion hazard is moderate. Fertility and the moisture-holding capacity are low. The soil is too stony for cultivation, and its use is limited to grazing. *Capability unit VIIs-1*

Redmond loam, 0 to 2 percent slopes (RdA).—This soil occurs in many individual areas and makes up about 30 percent of the total acreage in Redmond soils. These areas commonly range from 10 to 30 acres in size, but a few are larger than 100 acres. In most places this soil is in swales below Deschutes soils and other Redmond soils, and in places it is above Swartz silt loam, which lies in basins that have no outlet.

This soil is loam in the surface and subsurface layers and the upper subsoil, but otherwise it is similar to Redmond sandy loam, 0 to 2 percent slopes. The depth to bedrock ranges from 20 to 36 inches.

On this soil runoff is very slow, and the erosion hazard is only slight. The soil has moderate moisture-holding capacity and fertility. It is very easy to irrigate and to work. Because irrigation water is not available, many areas are used as range, but the soil is well suited to all crops grown locally. *Capability unit IIs-3*

Redmond stony loam, 0 to 6 percent slopes (RnB).—This is the least extensive of the Redmond soils. It generally occurs in areas of 10 to 30 acres and, in many places, adjoins areas of Rock land, Redmond loam, 0 to 2 percent slopes, and stony Redmond or Deschutes soils.

This soil has surface and subsurface layers of stony loam and an upper subsoil of loam, but in other respects it is similar to Redmond sandy loam, 0 to 2 percent slopes. The depth to bedrock ranges from 20 to 36 inches. In about three-fourths of the acreage, slopes range from 0 to 2 percent.

This soil has slow or very slow runoff, but it is slightly to moderately susceptible to erosion if it is irrigated. The moisture-holding capacity and fertility are moderate. The soil is slightly difficult or difficult to irrigate and is very difficult to work.

This soil is poorly suited to most crops grown in the Area. Under irrigation, it is best suited to plants used for pasture. *Capability unit IVs-2*

Riverwash (Rv)

This mapping unit occurs on alluvial flats, bars, and low levees along streams. It consists of barren deposits of sand and gravel that are subject to shifting when the water is high. The material is droughty and nearly bare of vegetation. Riverwash occurs mainly along the Crooked River. *Capability unit VIIIs-1*

Rock Land (Rx)

Rock land consists of loose stones, rock outcrops, and very shallow soil between the outcrops (fig. 11). This

Figure 11.—An area of Rock land and Deschutes soil under a stand of juniper, sagebrush, and bunchgrasses. Outcrops of basalt rock form similar knolls in many places west of the Dry River.

land type occurs in nearly level to very steep areas that range from five to several hundred acres in size. In most places the areas are so stony and so rocky that using farm machinery on them is impractical.

Rock land has slow to rapid runoff and is moderately susceptible to erosion. It is suitable as range, but its value for grazing is low. *Capability unit VIIs-1*

Rock Outcrop (Ry)

This miscellaneous land type occurs in areas of less than 5 to several hundred acres and consists mainly of bare bedrock. It has no agricultural value. *Capability unit VIIIs-1*

Salisbury Series

The Salisbury series consists of shallow to moderately deep, moderately dark colored, well-drained soils on old alluvial fans. These soils have a claypan subsoil underlain by a strongly cemented to indurated hardpan. They formed in gravelly alluvium that washed from higher slopes around Stearns Butte and was derived from basalt. The original plant cover consisted of sagebrush, bitterbrush, Idaho fescue, bluebunch wheatgrass, and juniper.

The surface layer of Salisbury soils is grayish-brown loam or very stony loam, about 4 inches thick. It is granular in structure and is neutral. The subsurface layer is similar to the surface layer but has a higher content of clay.

Below a depth of 8 to 14 inches, the subsoil is brown clay that contains many large, rounded fragments of basalt. This layer takes in water slowly when moist; it may be slightly calcareous in the lower part; and it overlies a hardpan at a depth of 16 to 24 inches. The hardpan commonly is 10 to 24 inches thick. In places it occurs on basalt bedrock.

The Salisbury soils are used as range and for dryland crops of grain.

Salisbury very stony loam, 0 to 6 percent slopes (SbB).—This nearly level or gently sloping soil occupies the high plateau a few miles southeast of Prineville. It occurs in only a few areas, but most of them range from 100 to 400 acres in size.

Representative profile:

0 to 8 inches, grayish-brown very stony loam that contains more clay in the lower part; slightly hard; neutral.
8 to 21 inches, dark-brown very stony clay; hard or very hard; neutral or mildly alkaline.
21 to 38 inches, light yellowish-brown, strongly cemented to indurated hardpan; calcareous; moderately alkaline.

The depth to the hardpan ranges from 16 to 24 inches. This soil has slow or very slow runoff, slow permeability, and low moisture-holding capacity and fertility. Erosion is only a slight hazard. Root growth is shallow to moderately deep. The soil is too stony for cultivation and is used for grazing. *Capability unit VIIs-4*

Salisbury very stony loam, 6 to 20 percent slopes (SbD).—Nearly all of this soil is in one area southeast of Prineville. The soil has a profile similar to that of Salisbury very stony loam, 0 to 6 percent slopes. Part of the acreage has been cleared of surface stones and was once used for cultivated crops.

This soil has slow to medium runoff and is likely to erode moderately if not protected. Fertility and the moisture-holding capacity are low. The soil is best used for grazing. *Capability unit VIIs-4*

Salisbury loam, 0 to 6 percent slopes (SaB).—This soil is inextensive and occurs in only a few areas. These areas range from 5 to 80 acres in size. Most of the acreage has been cleared of surface stones and cultivated, but otherwise the soil is similar to Salisbury very stony loam, 0 to 6 percent slopes. Included in areas mapped as this soil are a few small areas that have a surface layer of pumiceous sandy loam and generally are 4 to 10 inches deeper to hardpan.

On this soil runoff is slow or very slow. The erosion hazard is slight in range areas and is slight or moderate in fields used for dryfarming. Fertility and moisture-holding capacity are low.

This soil is far above irrigation canals. Dryland wheat and rye are grown on some of the acreage. *Capability unit IIe-4*

Searles Series

The Searles series consists of light-colored, well-drained soils that have a clay loam subsoil. These soils were derived from volcanic tuff and rhyolite on rolling to steep uplands under a cover of bluebunch wheatgrass, sagebrush, and scattered juniper. They occur principally north of Prineville and in the areas of Lone Pine and the Powell Buttes.

The surface layer of these soils is 4 to 6 inches of light brownish-gray to grayish-brown stony loam, clay loam, or sandy loam. This layer is neutral and has granular structure. The subsoil is grayish-brown, brown, or light olive-brown heavy loam or light loam that is very stony or very gravelly. The substratum is slightly calcareous very gravelly or very stony loam. Fragments of tuff or rhyolite occur, their number increasing with depth. Except in severely eroded Searles soils, bedrock of tuff or rhyolite is at a depth of 16 to 40 inches. In places the bedrock is capped by a hardpan that is strongly cemented with lime and silica.

The Searles soils are mainly in range.

Searles stony loam, 20 to 40 percent slopes (ScE).—A large acreage of this soil occurs in the Powell Buttes area. In addition, there is a tract of about 500 acres in the Lone Pine area. Most of the remaining acreage is in tracts of 20 to 200 acres north and south of Prineville. Slopes range from 25 to 35 percent in most places.

Representative profile:

0 to 8 inches, grayish-brown stony loam; slightly hard; neutral.
8 to 25 inches, brown to dark-brown very gravelly or very stony loam or clay loam; hard; neutral.
25 to 40 inches, brown very gravelly or very stony loam; hard; neutral; slightly calcareous.
40 inches +, rhyolite bedrock capped by 1 to 4 inches of strongly cemented hardpan of lime and silica.

In a few areas, principally on north-facing slopes, there are few or no stones in the profile. The underlying bedrock is capped by a hardpan only in places. The depth to bedrock ranges from 24 to 40 inches.

On this soil runoff is medium to rapid, permeability is moderately slow, and the erosion hazard is moderate to severe. The moisture-holding capacity and fertility are moderate. Roots penetrate deeply. Because the soil is steep and stony, its use is limited to range. *Capability unit VIe-1*

Searles stony loam, 2 to 20 percent slopes (ScD).—This soil is commonly in areas of 10 to 50 acres. Most of it is on the Powell Buttes, and the rest is on the buttes north of Prineville. At least three-fourths of the acreage has slopes of more than 6 percent.

This soil is similar to Searles stony loam, 20 to 40 percent slopes, but is not so steep. It is underlain by bedrock at a depth of 24 to 40 inches. A few small areas have few or no stones in the profile.

On this soil runoff is slow to medium, and the risk of erosion is slight to moderate. Because the soil is stony, it is difficult to cultivate and is more suitable for range than for cultivation. *Capability unit VIe-1*

Searles stony clay loam, 6 to 20 percent slopes (SdD).—This inextensive soil occurs in small areas of 5 to 20 acres. Its present surface layer is stony clay loam because the original surface layer of loam has been lost through erosion or has been mixed with subsoil material in cultivation. The depth to tuff bedrock is 16 to 32 inches.

This soil has medium to rapid runoff and is moderately susceptible to further erosion. The moisture-holding capacity and fertility are low to moderate. The soil is very difficult to work and is most suitable as rangeland. *Capability unit VIe-1*

Searles stony clay loam, 20 to 40 percent slopes, severely eroded (SdE3).—This soil has lost all of its original surface layer and most of its subsoil through erosion. In most places it is 6 to 18 inches deep over tuff bedrock, but in many spots the bedrock is exposed. The soil is inextensive and occurs in only a few areas of 25 to 50 acres.

This soil has rapid runoff and is highly susceptible to further erosion. It is low in fertility and moisture-holding capacity, and it produces little forage. *Capability unit VIIs-3*

Searles stony sandy loam, 6 to 20 percent slopes (SeD).—This soil is mainly in tracts of 5 to 30 acres north of Prineville and on the Powell Buttes. In most places it is below steeper Searles soils and above Ayres, Ochoco, or Prineville soils.

The surface layer of this soil is neutral, grayish-brown to light brownish-gray stony sandy loam 3 to 8 inches thick. This layer has been strongly influenced by a layer of material containing a large amount of pumice. The upper part of the thin subsoil is neutral, brown sandy loam 3 to 10 inches thick. At a depth of 8 to 18 inches is a lower subsoil of clay or clay loam 4 to 12 inches thick. The lower subsoil contains fragments of tuff and is calcareous a few inches above bedrock. The depth to bedrock is only 16 to 24 inches.

On this soil runoff is slow to medium, permeability is moderately slow or slow, and the erosion hazard is moderate. Fertility and the moisture-holding capacity are low. The soil is difficult to cultivate and is best suited to range plants. *Capability unit VIe-1*

Searles stony sandy loam, 20 to 40 percent slopes (SeE).—About half of this soil occurs as a single tract on the buttes northeast of Prineville. The rest is in tracts of 10 to 60 acres in the same area and in the vicinity of the Powell Buttes. Except for its surface and subsurface layers of stony sandy loam or stony fine sandy loam, this soil is similar to Searles stony loam, 20 to 40 percent slopes.

This soil has medium to rapid runoff and is likely to wash moderately or severely if left unprotected. It is moderately susceptible to wind erosion. Fertility and the moisture-holding capacity are low. The soil is too stony and too steep for cultivation and is best used as rangeland. *Capability unit VIe-1*

Searles-Slayton complex, 2 to 20 percent slopes (SfD).—This complex occurs in areas of 5 to 100 acres. About 60 percent of the acreage is on side slopes and consists of a soil that is similar to Searles stony sandy loam, 6 to 20 percent slopes. The rest is on hilltops and consists of a soil that is like Slayton sandy loam, 2 to 20 percent slopes.

Most of this complex is above present irrigation canals, but a few small areas occur below the canals and are cultivated. *Searles soil: capability unit VIe-1; Slayton soil: capability unit IVe-1*

Searles-Slayton complex, 20 to 40 percent slopes (SfE).—At least 50 percent of this complex is Slayton channery sandy loam, 20 to 40 percent slopes, and the rest is a soil that has a profile similar to that of Searles stony sandy loam, 6 to 20 percent slopes. The depth to bedrock is 8 to 16 inches in the Slayton soil and is 16 to 24 inches in the Searles soil. Several areas of 100 acres or more account for most of the acreage in the complex.

These soils are best suited to range because they are steep, stony, and shallow to bedrock. *Capability unit VIe-1*

Slayton Series

In the Slayton series are light-colored, well-drained soils that occupy low foothills north and northeast of Prineville. These soils were derived from greenish tuff or breccia that was mixed with pumice sand, especially in the upper layers. The original plant cover consisted mainly of bluebunch wheatgrass and needlegrass, but most of these grasses have been replaced by rabbitbrush and cheatgrass.

The Slayton soils have a surface layer of neutral, light brownish-gray sandy loam 2 to 6 inches thick. In this layer are greenish chips and pebbles of tuff, some pumice sand and, in many places, few to many channery fragments. The subsurface layer is 2 to 8 inches thick and is similar to the surface layer, but it contains less pumice and has a higher content of coarse fragments. The subsoil is 4 to 10 inches of neutral, light brownish-gray sandy loam that has more and larger tuff fragments than the upper layers. Bedrock occurs at a depth of 8 to 20 inches.

Nearly all the acreage of Slayton soils is in range.

Slayton sandy loam, 2 to 20 percent slopes (SkD).—This soil is on ridges or saddles and in rolling areas. It is mainly in tracts of 5 to 30 acres, though in several areas it covers more than 100 acres. Slopes generally range from 6 to 20 percent.

Representative profile:

0 to 8 inches, light brownish-gray sandy loam; soft; neutral.
8 to 14 inches, pale-brown channery sandy loam; soft; neutral.
14 inches +, light yellowish-green sandy tuff.

The depth to bedrock is 12 to 20 inches.

Although this soil has slow to medium runoff and rapid permeability, it is subject to moderate or severe erosion if it is not protected. The soil is low in fertility and moisture-holding capacity and has a shallow root zone. It is difficult or very difficult to irrigate and is slightly to very difficult to work.

This soil is suited to irrigated pasture and to small grain, but it is poorly suited to potatoes, other row crops, and alfalfa. Most of the acreage is in range. *Capability unit IVe-1*

Slayton channery sandy loam, 2 to 20 percent slopes (ShD).—In most places this soil is in areas of 5 to 50 acres that commonly lie below areas of Searles soils or Slayton channery sandy loam, 20 to 40 percent slopes, and above areas of Prineville and Ochoco soils. This soil has many fragments of sandy tuff on the surface and throughout the profile, but in other respects it is like Slayton sandy loam, 2 to 20 percent slopes. The depth to bedrock ranges from 8 to 20 inches.

Runoff is slow to medium, the erosion hazard is moderate, and the moisture-holding capacity and fertility are low. The soil is too stony and too shallow for cultivation, and nearly all the acreage is in range. *Capability unit VIe-1*

Slayton channery sandy loam, 20 to 40 percent slopes (ShE).—In many places this soil is above other Slayton soils. It occurs mainly in areas of 10 to 30 acres, though one area covers nearly 200 acres. The soil is similar to Slayton sandy loam, 2 to 20 percent slopes, but it is steeper and has many fragments of sandy tuff on the surface and throughout the profile. The depth to bedrock ranges from 8 to 16 inches.

On this soil medium to rapid runoff causes a moderate or severe hazard of erosion. Fertility and the moisture-holding capacity are low. The soil is used as range; it is too steep, too stony, and too shallow for cultivation. *Capability unit VIe-1*

Stearns Series

The Stearns series consists of nearly level, light-colored, imperfectly drained soils that developed in alluvium and occupy low terraces along the Crooked River and Ochoco Creek, where the water table is high. These soils have a slowly permeable subsoil that overlies a hardpan weakly cemented by lime. The plant cover is mainly greasewood, saltgrass, giant wildrye, and rabbitbrush.

Stearns soils have a surface layer of light brownish-gray, neutral silt loam that is about 5 inches thick and slightly hard when dry. The subsoil of brown silty clay loam or silt loam is hard, slightly calcareous, and very strongly alkaline. The hardpan occurs at a depth of 12 to 30 inches and is irregular and discontinuous. Below the pan are layers of silt and sand that were deposited by water. Free water occurs at the pan or just below it.

These soils are moderately or strongly alkali and slightly or moderately saline. Grazing is the principal use, though some areas have been reclaimed and irrigated.

Stearns silt loam (Sl).—This nearly level soil is in areas that range from less than 5 to 100 acres in size. The smaller areas are irregular in shape but are commonly long and narrow, whereas the larger ones are oblong.

Representative profile:

0 to 5 inches, light brownish-gray silt loam; slightly hard; neutral.
5 to 13 inches, brown silty clay loam; hard; slightly calcareous; very strongly alkaline.
13 to 36 inches, light brownish-gray silt loam; weakly lime-cemented hardpan; slightly to strongly calcareous; very strongly alkaline.
36 to 60 inches, pale-brown, stratified silt loam to fine sandy loam; slightly hard; slightly calcareous; strongly alkaline.

In some places where plowing has mixed the original surface layer with subsoil material, the present surface layer is silty clay loam. The depth to the hardpan ranges from 12 to 30 inches. This soil has a moderate or high content of alkali and is slightly or moderately saline. If cultivated and irrigated, the soil readily puddles.

This soil has very slow runoff and is only slightly susceptible to erosion. It is slowly permeable and has low moisture-holding capacity. The fertility is low. Root growth is shallow. Because of alkali, the soil is difficult to irrigate and to work.

Unless this soil is reclaimed, its use is limited to grazing. *Capability unit IVw-3*

Stearns-Crooked complex (Sm).—This nearly level complex is made up of two soils that occur in an intricate pattern. One soil is like Crooked loam, 0 to 2 percent slopes, and the other is like Stearns silt loam. About 75 percent of the complex is in the city of Prineville, and the rest consists of only a few individual areas.

Unless the concentration of alkali is reduced, agricultural use of the soils is limited to livestock grazing. *Stearns soil: capability unit IVw-3; Crooked soil: capability unit IIIw-2*

Steiger Series

Soils of the Steiger series are nearly level or gently sloping, moderately dark colored, and well drained. These soils are on the forested upland east of Prineville and on alluvial fans above bottom land, mainly along Ochoco Creek. The native vegetation consists chiefly of Ponderosa pine, perennial grasses, bitterbrush, and sagebrush.

Steiger soils have a neutral, grayish-brown sandy loam or loam surface layer 5 to 8 inches thick. The subsurface layer, 6 to 12 inches thick, is sandy loam that is slightly browner and lighter colored than the surface layer. The lower layers consist of sandy loam that is lighter in color and less acid with increasing depth.

These soils are used for grazing in summer.

Steiger sandy loam (Ss).—This inextensive soil is generally in small areas of less than 5 to 15 acres. Slopes range from 0 to 6 percent.

Representative profile:

0 to 14 inches, grayish-brown sandy loam; soft or slightly hard; neutral.
14 to 28 inches, brown to pale-brown sandy loam; soft or slightly hard; neutral or mildly alkaline.
28 to 69 inches, pale-brown stratified sandy loam and fine sandy loam; soft; mildly alkaline.

The texture of the surface layer ranges from sandy loam to loam. In about 40 percent of the acreage, the subsoil is pumiceous sand or loamy sand below a depth of about 20 inches, and there are basaltic pebbles below a depth of about 3 feet.

This soil has slow or very slow runoff and rapid permeability. The hazard of erosion ranges from none to moderate, depending on slope. The moisture-holding capacity and fertility are moderate. Roots penetrate deeply. The soil is easily worked and can be irrigated with little or no difficulty.

Most of this soil is in pasture that is grazed mainly in summer. Because the growing season is short and frost is a hazard, potatoes and similar crops are not suitable. *Capability unit IIIs-2*

Swartz Series

The Swartz series consists of fine-textured, imperfectly drained soils on the upland plateau west of Prineville. These soils occupy basins that have no outlets. They developed in material that weathered from pumice and volcanic ash and in mixed sediments that washed into the basins. The plant cover is made up of silver sagebrush, annual grasses, and a small amount of rabbitbrush.

The surface layer is gray to light-gray silt loam, loam, or silty clay loam 4 to 10 inches thick. This layer tends to seal up when wet and cracks as it dries. In many places water stands on the surface after a rain.

Underlying the surface layer is a subsoil of grayish-brown or light brownish-gray clay or silty clay that is neutral or mildly alkaline. The subsoil shrinks when it dries and swells into a massive, tightly sealed layer when wet. Water enters this layer very slowly, and roots penetrate it, mainly in cracks, to a depth of about 18 inches. The lower part of the subsoil is grayish-brown clay or silty clay. The substratum is grayish-brown to light yellowish-brown clay or silty clay.

Swartz soils are used for grazing.

Swartz silt loam (Sw).—More than half of this soil occurs on the plateau in the vicinity of the Prineville Airport, and the rest is near Huston Lake and on the plateau west of the Dry River. The soil commonly forms circular or oblong basins that have no outlet. Most areas range from 5 to 40 acres in size, but an area near the airport is larger than 100 acres. Slopes are generally less than 2 percent, though a few small areas have slopes of 4 or 5 percent. In many places the soil is surrounded by Redmond soils.

Representative profile:

0 to 5 inches, gray to light-gray silt loam; soft or slightly hard; slightly acid or neutral.
5 to 32 inches, grayish-brown clay or silty clay; hard; neutral or mildly alkaline.
32 to 60 inches, grayish-brown to dark grayish-brown clay or silty clay; hard when dry, sticky when wet; mildly alkaline.

In areas near Huston Lake, this soil is wetter than in other areas, and its subsoil is darker, mottled, and less clayey. Included in areas mapped as this soil are areas that have a silty clay loam surface layer.

This soil has very slow runoff, and there is little or no erosion hazard. Permeability is slow. The moisture-holding capacity and fertility are low. Root growth is shallow to moderately deep. Irrigating the soil is very easy, but working it is slightly difficult to very difficult.

This soil is moderately well suited to all crops grown locally, but included areas that have a silty clay loam surface layer are poorly suited to potatoes. Most of the soil is in uses other than cultivated crops. Material from the subsoil is used for sealing ponds. *Capability unit IVw-1*

Veazie Series

The Veazie series consists of moderately dark colored, well-drained or somewhat excessively drained soils on bottom land along Ochoco, Mill, McKay, and Veazie Creeks. These soils formed in sediments that washed from soils derived from several kinds of rocks, chiefly basalt. The original vegetation was mainly grasses, and there were a few willows along the stream channels.

Veazie soils have a surface layer of neutral, dark-gray loam, gravelly loam, or gravelly sandy loam 6 to 12 inches thick. The subsoil is similar but is lighter colored and browner. Below a depth of 15 to 20 inches is a layer of sand and silt that is underlain, at a depth of 18 to 40 inches, by very gravelly or sandy material similar to riverwash.

The Veazie soils are used for irrigated hay and pasture.

Veazie loam (Va).—Most of this nearly level soil occurs along McKay and Ochoco Creeks. Many of the small areas are long and narrow, and they parallel the stream channel. Some areas along McKay Creek are somewhat oblong. Slopes generally range from 0 to 2 percent, but about 10 percent of the acreage has slopes of 2 to 6 percent. In many places this soil is flooded for short periods in spring.

Representative profile:

0 to 8 inches, dark-gray loam; soft; neutral.
8 to 24 inches, grayish-brown, stratified loam, silt loam, and very fine sandy loam; slightly hard; neutral.
24 inches +, grayish-brown very gravelly sand; loose; neutral.

The depth to gravel or sand ranges from 20 to 40 inches.

This well-drained soil has very slow runoff, is moderately permeable, and is subject to only slight erosion. The moisture-holding capacity and fertility are moderate. Roots grow to a moderate depth. The soil is very easy to irrigate and to work.

Except along McKay Creek where frost is not a hazard, this soil is not suited to potatoes. It is best suited to irrigated hay and pasture. *Capability unit IIIs-2*

Veazie loam, shallow (Vb).—Most areas of this nearly level soil range from 5 to 15 acres in size, and many of them are long and narrow. The soil generally is flooded for short periods in spring.

In this soil the depth to very gravelly or sandy material is 18 to 20 inches, and the loam surface layer and subsoil are gravelly in a few areas. Otherwise the soil is like Veazie loam.

This soil is somewhat excessively drained. It has very slow runoff and moderate permeability, and it is only slightly susceptible to erosion. The moisture-holding capacity and fertility are low. Root growth is shallow. The soil is very easy to irrigate and to work.

Because of the frost hazard, this soil is poorly suited to potatoes. It is best suited to irrigated hay and pasture. *Capability unit IIIs-2*

Veazie gravelly loam (Vg).—This soil is mainly along Mill Creek and Ochoco Creek. In most places it occurs in areas of 5 to 15 acres that are long and narrow and are parallel to the stream channel. The soil is commonly flooded for short periods in spring.

Except for its gravelly surface layer and its 24- to 30-inch depth to very gravelly and sandy material, this soil is similar to Veazie loam. About 10 percent of the acreage is on alluvial fans that have slopes of 2 to 12 percent. Included in areas mapped as this soil are a few areas that are gravelly or cobbly sandy loam throughout the profile.

This soil is well drained and moderately permeable. It has very slow runoff and is only slightly susceptible to erosion. Its moisture-holding capacity and fertility are low to moderate. Roots penetrate to a moderate depth. The soil is very easily irrigated and can be worked with little difficulty.

This soil is best suited to irrigated hay and pasture. It is poorly suited to potatoes because it occurs in areas where frost is a hazard. *Capability unit IIIs-2*

Veazie-Riverwash complex (Vr).—This complex occurs along the channels of streams, chiefly Mill Creek and Ochoco Creek, and is made up of Veazie loam and Riverwash that are closely intermingled because of the many channels cut during spring floods. About 60 percent of the complex is Veazie loam, and the rest is Riverwash. Although some areas are as small as 5 acres, most of the acreage is in several areas of 50 acres or more that are 150 to 400 feet wide and ½ to 1 mile or more long.

The Veazie soil is suited to hay and pasture, but its use is limited by channels and areas of Riverwash. *Veazie loam: capability unit IIIs-2; Riverwash: capability unit VIIIs-1*

Formation, Classification, and Morphology of Soils[2]

This section has five main parts. The first explains the five factors of soil formation; the second discusses genetic relationships and processes; the third classifies the soils by orders and great soil groups; the fourth gives detailed profile descriptions of representative soils in the Prineville Area; and the fifth provides laboratory data on selected soil profiles.

Factors of Soil Formation

Five factors have determined the formation of soils in the Prineville Area. These factors are (1) climate, (2) organisms, chiefly vegetation, (3) parent material, (4) relief, or lay of the land, and (5) time. Except for time, each of these consists of many individual factors. Climate, for example, is made up of temperature, the amount

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[2] E. G. Knox, associate professor of soils, Oregon State University, prepared this section.

of sunshine, the amount and distribution of rainfall, and so on. Moreover, one group of factors influences another. Vegetation is largely, though not entirely, controlled by climate. The degree of horizon development, which reflects the age of a soil, depends partly on relief. Characteristics of any soil are determined by and can be explained by the interaction of these five factors. Table 5 shows the great soil group, selected characteristics, and parent material of each soil series in the Prineville Area.

Climate

The climate of the Prineville Area is semiarid, and most of the annual precipitation occurs in winter. Climatic data for the Area are given in the section "Facts About Crook County."

Climate influences the formation of soils directly and through control of the kind and amount of native vegetation. In this Area three direct influences are most important. First, temperature in winter is so low that the soils are frozen for a long period. During this period the intake of moisture and many processes of soil formation are completely stopped. Second, the total precipitation and its seasonal distribution are such that most soils thoroughly dry out each summer. Third, the intake of precipitation is confined to a fairly short period, and consequently the depth of leaching is great compared to the amount of precipitation.

Organisms

Although rodents and ants mix materials of soil horizons and thus retard their development, plants are much more important than animals in determining the formation of soils. In general, there are two climate-vegetation zones in the Area. In the lower rainfall zone, or the zone of Brown soils, the depth and the amount of leaching are less than in the higher rainfall zone, or the zone of Chestnut soils.

In well-drained locations throughout the zone of lower rainfall, the original vegetation was chiefly bluebunch wheatgrass and Sandberg bluegrass. Big sagebrush made up part of the plant cover, but there was no Idaho fescue or bitterbrush. In the zone of higher rainfall, the vegetation consisted of a dense stand of bluebunch wheatgrass and some Sandberg bluegrass, Idaho fescue, big sagebrush, and bitterbrush.

Plants in these two kinds of cover supplied different amounts of organic matter to the soils on which they grew. The Chestnut soils received the larger amounts and have a thicker, darker A horizon. Laboratory analysis shows that they also have a higher organic-matter con-

TABLE 5.—*Soil series of the Prineville Area and their classification, selected characteristics, and parent material*

Soil series	Great soil group	Degree of B horizon development	Hardpan	Natural drainage	Parent material
Agency	Brown	Moderate	None	Good	Material weathered from pumice, sandstone, and basalt.
Ayres	Brown	Moderate	Indurated	Good	Fan alluvium from rhyolite and pumice.
Bakeoven	Brown	Moderate	None	Good	Material weathered from basalt.
Boyce	Humic Gley	None	None	Poor or very poor	Flood-plain alluvium from mixed rocks.
Courtrock	Brown	None	None	Good	Fan alluvium from basalt and tuff.
Crooked	Alluvial	None	Strong	Imperfect	Flood-plain alluvium from pumice.
Day	Grumusol	None	None	Good	Material weathered from tuff.
Deschutes	Brown	None	None	Good or somewhat excessive.	Material weathered from pumice.
Elmore	Chestnut	Moderate	None	Good	Material weathered from rhyolite.
Forester	Alluvial	None	None	Imperfect	Flood-plain alluvium from pumice.
Gem	Chestnut	Moderate	None	Good	Material weathered from basalt.
Lamonta	Brown	Strong	Indurated	Good	Fan alluvium from rhyolite.
Lookout	Brown	Strong	Strong	Good	Colluvium from basalt.
Metolius	Alluvial	None	None	Good or somewhat excessive.	Flood-plain alluvium from pumice.
Ochoco	Brown	Moderate	Weak to strong	Good	Terrace and fan alluvium from basalt.
Ontko	Humic Gley	None	None	Poor or very poor	Flood-plain alluvium from mixed rocks.
Polly	Chestnut	Moderate	None	Good	Fan alluvium from basalt and tuff.
Powder	Alluvial	None	None	Good or moderately good.	Flood-plain alluvium from mixed rocks.
Prineville	Brown	None	Weak to strong	Good	Terrace and fan alluvium from basalt.
Redmond	Brown	Moderate	None	Good	Material weathered from pumice.
Salisbury	Chestnut	Strong	Strong or indurated.	Good	Fan alluvium from basalt.
Searles	Brown	Moderate	Strong or indurated.	Good	Material weathered from tuff and rhyolite.
Slayton	Lithosol	None	None	Good	Material weathered from sandy tuff.
Stearns	Solonetz	Moderate	Weak	Imperfect	Flood-plain alluvium from mixed rocks.
Steiger	Regosol	None	None	Good	Fan alluvium from volcanic ash.
Swartz	Soloth	Moderate	None	Imperfect	Material weathered from pumice and sorted by water.
Veazie	Alluvial	None	None	Good or somewhat excessive.	Flood-plain alluvium from mixed rocks.

tent and a higher carbon-nitrogen ratio. For example, in an Elmore soil sampled on a north slope, the average content of organic matter was 4.1 percent, and the average carbon-nitrogen ratio was 13.2 in the A1 horizon. In contrast, a Searles soil was sampled on a south slope, and this Brown soil had an average organic-matter content of 1.7 percent and an average carbon-nitrogen ratio of 10.8.

Areas that are not well drained have a cover of native plants that differs from the two types common in well-drained areas. On the flood plain of streams, grasses, sedges, and rushes grow in various combinations where the soils are wet for long periods but are not affected by alkali. This vegetation supplies an abundance of organic matter, and the soils have a thick, dark-colored A horizon. Silver sagebrush is dominant in places that accumulate water but are not wet for long periods. Such areas are the small depressions of Swartz soil on the upland plateau west of Prineville. Greasewood and saltgrass are the principal plants in wet areas affected by alkali.

Parent material

The soils of the Prineville Area have formed from five kinds of parent material: (1) material resulting from the weathering of bedrock and local movement on sloping uplands and plateaus, (2) alluvium deposited in alluvial fans and ranging widely in size of particles, (3) gravelly or sandy alluvium on terraces, (4) pumice on uplands from geologically recent volcanic explosions, and (5) stream alluvium on flood plains and low benches.

The size of particles, mineralogy, and thickness of the parent material have greatly influenced the nature of the soils. Some soil characteristics are inherited directly from the parent material. For example, the materials on uplands have produced soils that are generally shallow to bedrock and stony, except for those that overlie the soft, clayey rocks of the John Day and Clarno formations (*2*). Soils formed in material on alluvial fans and terraces generally are somewhat gravelly or cobbly.

Some soils have inherited their light weight and sandy characteristics directly from pumice. The Deschutes and Redmond soils were derived from pumice in place; the Steiger soils developed in pumicy material redeposited in alluvial fans; and the Metolius, Crooked, and Forester soils developed in pumicy material on flood plains. Except for the Stearns soils, other soils developed in flood-plain alluvium inherited their texture from parent material.

Other characteristics of soils are influenced less directly by parent material. The cracking and churning in the Day soils are the result of a high clay content and the mineralogy of the tuff materials from which the soils formed. Various proportions of tuff and basalt from the Clarno formation may have caused the difference in texture between the Courtrock and the Polly soils. In addition, the difference in textural development between the Prineville and the Ochoco soils, as shown by their clay content (see table 11, p. 78), may be caused by a difference in parent material. Other influences of parent material are less evident and are described in the subsection "Descriptions of Soil Profiles."

Relief

Relief is strongly related to the origin of parent material. Thus, the materials weathered from bedrock and moved locally are on the nearly level to very steep slopes of hills and upland plateaus. Soils from material on terraces are nearly level, except those on escarpments and in drainageways cut into the terraces. Soils from recent alluvium are level except in places where stream channels occur, and they may have a water table that is high enough to influence soil development.

Aspect, or the direction a slope faces, is an important part of relief. It strongly influences the exposure of soils to the sun and the disposition of precipitation. South-facing slopes are warmer and dryer than north-facing slopes, and this difference is equivalent to an actual difference in rainfall. Some hills have a plant cover that is typical of Brown soils on south slopes and of Chestnut soils on north slopes. Laboratory analysis indicates that soils on south slopes differ from those on north slopes in having a lower content of organic matter and a lower carbon-nitrogen ratio, and they are less leached, as shown by the degree of base saturation. For example, Elmore very stony loam occurs on north slopes and has an average base saturation of about 80 percent in the A horizon, but a Searles soil that occurs on south slopes has an average base saturation of about 85 percent in the A horizon.

If other factors are constant, steep soils tend to have less distinct horizons than more gently sloping soils, probably because geologic erosion is faster on steep slopes and less water is absorbed for use in soil development.

Natural drainage is influenced by relief and parent material. Well-drained soils are not wet for any significant period of time, but poorly drained soils are wet for long periods. Natural drainage is an important soil characteristic in itself, and it also has an indirect effect on the kind and amount of vegetation. Soils can be made saline or sodic through the influence of ground water. Most soils in the Prineville Area are well drained, and the wetter soils occur only on flood plains and in depressions on the upland plateau.

Time

The formation of soil from parent material takes time. If factors other than time are equal, young soils have less distinct horizons than old soils.

Most soils that formed in upland materials are old enough to have moderately or strongly developed horizons. In this Area, however, some of these soils are weakly developed. Day clay is a weakly developed soil, presumably because it was so dominated by clay inherited from the parent material that not much development was possible. It is presumed that geologic erosion was responsible for the weak development of the Slayton soils.

Soils that formed on alluvial fans vary in age and in degree of development. Most fans consist of material that was not deposited uniformly but was shifted from place to place. In soils that developed in fan alluvium derived from similar parent rock, it is not known how much of the difference in degree of development can be attributed to a difference in age of the alluvium and how much to difference in texture and mineralogy of it.

Soils that formed on terraces are younger and less strongly developed than most soils that formed on uplands. The degree of development varies in these soils on terraces, probably because of differences in texture of the terrace material.

The pumice in the Prineville Area was laid down in geologically recent times, and the soils that formed in it are not strongly developed. The Deschutes and the Redmond soils differ in their degree of development, but the difference is probably not a result of a difference in age. It may be caused by a difference in the material underlying the pumice or a difference in the amount of water available for weathering because of unlike relief. Although the Swartz soils developed partly in material that weathered from pumice, their development is stronger than that of the Deschutes and Redmond soils, likely because of a difference in the availability of water or a difference in texture caused by water sorting the parent material of the Swartz soils.

Soils that formed in recent alluvium are young and generally are weakly developed. Of these, the Stearns soils are the most strongly developed. They occur on an older bench and have a high percentage of exchangeable sodium, which can speed the process of soil development. The Crooked and Forester soils also occur on older benches but are weakly developed, though they have a strongly to weakly developed hardpan. The reason for this difference is not known. Other soils from recent alluvium are weakly developed.

TABLE 6.—*Soils of the Prineville Area arranged by parent material, parent rock, and degree of development*

Dominant parent material and parent rock	Degree of development [1]		
	Textural B horizon weak or none	Textural B horizon moderate	Textural B horizon strong
Upland material:			
Basalt		Bakeoven, Gem.	Lookout.
Rhyolite		Searles, Elmore.	
Tuff	Day	Searles	
Sandy tuff	Slayton		
Sedimentary beds.		Agency	
Pumice, mostly in place but some windlaid.	Deschutes	Redmond	
Pumice, sorted by water.		Swartz	
Alluvial-fan material:			
Basalt			Salisbury.
Rhyolite		Ayres	Lamonta.
Mixed basalt and tuff.	Courtrock	Polly	
Pumice	Steiger		
Alluvial-terrace material:			
Basaltic mixture	Prineville	Ochoco	
Flood-plain alluvium:			
Pumice	Crooked, Forester Metolius.		
Mixed	Boyce, Powder, Ontko, Veazie.	Stearns	

Genetic Relationships and Processes

The relationships of soil series in the Prineville Area to the factors of soil formation, and to one another, are shown in tables 6, 7, 8, and 9. Only the most obvious relationships can be expressed in these tables. Detailed information about the soils is given in the subsections "Descriptions of Soil Profiles" and "Laboratory Data" and in the section "Descriptions of Soils."

TABLE 7.—*Selected soil series arranged according to sources of parent material and their geologic formations*

Geologic formation and type of rock	Parent material	
	Material on uplands	Material on alluvial fans
Clarno:		
Tuff	Searles	
Sandy tuff	Slayton	
Basalt	Gem	
Rhyolite	Searles, Elmore	Ayres, Lamonta.
Mixed basalt and tuff		Courtrock, Polly.
John Day	Day	
Columbia River basalt	Lookout, Gem	Salisbury.
Dalles:		
Sedimentary beds	Agency	
Basalt	Bakeoven	
Intracanyon	Bakeoven	

Soils in this Area have formed from parent material through the interaction of many physical, chemical, and biological processes. The same general processes have acted on the parent material of all the soils in the Area and on the parent material of all the soils in the world. Differences in soils are the result of differences in parent material and in the relative effects of the various processes controlled by the other factors of soil formation.

Most of our information about the genetic processes is inferred from our knowledge of the results of these processes. In soils of the Prineville Area, the most important features produced by genetic processes are (1) an A horizon that has an accumulation of organic matter, (2) a B horizon that has an accumulation of silicate clay, (3) a hardpan, presumably cemented by alkali-soluble material, in well-drained and imperfectly drained soils, (4) soft consistence and platy structure in the A horizon of some soils, (5) calcium carbonate in the lower horizons of some soils and fairly high base saturation, and (6) high sodium saturation in some soils. Each of these features is discussed in the paragraphs that follow.

The A horizon

The amount of organic matter in the A horizon is a balance between additions, mainly from higher plants, and losses, mainly from oxidation, caused by decomposition and the return of oxidation products to the atmosphere. In Chestnut soils the balance between additions and losses is at a higher level of organic matter than in Brown soils, presumably because of differences in kind

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[1] The degree of development is determined by time, relief, and parent material.

Table 8.—*Relationship of some soils and their parent material to native vegetation and average annual precipitation*

Dominant parent material and parent rock	Soils formed under—	
	Big sagebrush, bluebunch wheatgrass, and Sandberg bluegrass where precipitation is 8 to 10 inches	Idaho fescue, bluebunch wheatgrass, Sandberg bluegrass, big sagebrush, and bitterbrush where precipitation is 11 to 13 inches
Material on uplands:		
Basalt	Bakeoven, Lookout.	Gem.
Rhyolite	Searles	Elmore.
Tuff	Searles	
Sandy tuff	Slayton	
Sedimentary rocks	Agency	
Pumice, windlaid	Deschutes, Redmond.	
Material on alluvial fans:		
Basalt	----------	Salisbury.
Rhyolite	Ayres, Lamonta	
Mixed rocks, chiefly basalt and tuff.	Courtrock	Polly.
Material on alluvial terraces from a basaltic mixture.	Prineville, Ochoco	

and amount of plant cover. (See table 11, p. 78, for laboratory analyses of an Elmore soil and of Ayres, Ochoco, Prineville, and Searles soils.)

Wet soils affected by alkali have a low organic-matter content because the plants tolerant of alkali do not supply much organic matter. (See laboratory analysis for the Crooked soils in table 11.) In imperfectly drained and poorly drained soils that are not affected by alkali, the organic-matter content is high because the plants make large additions and wetness retards oxidation. Laboratory data for the Swartz soil (see table 11) show that a fairly high level of organic matter can be built up even by silver sagebrush, but the Boyce and Ontko soils have a significantly higher organic-matter content.

The B horizon

Laboratory data on the content of clay indicate that the Ayres, Lamonta, Ochoco, Searles, Stearns, and Swartz are among the soils that have a textural B horizon. An accumulation of clay forms a textural B horizon if (1) the relative concentration of clay in the horizon increases because other constituents are removed, (2) the formation of clay from primary minerals is greater in the B horizon that in other horizons, or (3) clay or clay constituents are transferred into the B horizon. The relative importance of these alternatives is not known.

The soils having the most strongly developed textural B horizons are on upland hills and on alluvial fans. Soils that developed in material from basalt or rhyolite appear to be very old. Basalt and rhyolite contain no clay and, in soils derived from them, it is likely that the clay formed from primary minerals at some stage in soil formation. Consequently, the strong development of the B horizon in these soils is best explained by their great age.

The Polly soils developed from parent material that contained fragments of tuff rock. In these soils the high clay content may be the result of a fairly simple breakdown in tuff fragments. However, the Courtrock soils have similar parent material but are not strongly developed. Whether the textural B horizon in the soils of these two series differs in degree of development because of small differences in parent material or differences in age is not known.

Most other soils that occur in upland areas but lack a strong textural B horizon likely are younger than the Polly and Courtrock soils. The Day soils have no textural B horizon, though they are old and developed from clayey parent material. These soils, however, have a high content of clay that swells when wet and shrinks as it dries—a process that churns and mixes the soil material and thus prevents formation of a B horizon. In the Steiger soils a textural B horizon has not developed, because the parent material of volcanic ash is very young.

The Prineville and the Ochoco soils developed side by side on the same terrace, but no reason is evident for a difference in genetic processes that formed them. Presumably there were small differences in parent material that caused the difference in degree of textural development.

The Deschutes soils are weakly developed because they are from young parent material. The Redmond and probably the Swartz soils are from pumice of the same age, but the Swartz soils have a higher content of clay, possibly because a greater amount of moisture was available for weathering. Sorting of the pumice by water may have provided finer textured parent material for the Swartz soils.

All soils on flood plains except the Stearns show little if any development of a textural B horizon. These soils are too young for the movement of clay through genetic

Table 9.—*Relation of parent material and natural drainage to soils that formed in weathered pumice or in flood-plain alluvium*

Parent material	Natural drainage		
	Somewhat excessive to moderately good	Imperfect	Poor or very poor
Pumice:			
Mostly in place	Deschutes, Redmond.	----------	
Sorted by water	----------	Swartz	
Flood-plain alluvium:			
On older benches	----------	Crooked, Forester, Stearns.	
On younger benches.	Metolius, Powder, Veazie.	----------	Boyce, Ontko.

processes. The Stearns soil occurs on an older bench and has high sodium saturation, which hastens the transfer of clay from one horizon to another.

Hardpan

A hardpan consists of siliceous material that has accumulated in a horizon more or less well defined. In well-drained soils the cementing material occurs in rounded forms that hang on the bottom of rock fragments. This indicates that the material precipitated from solution and accumulated through downward movement, and it implies that siliceous material was brought down in solution from upper horizons. The present pH values in these soils are not high enough to account for much solution of silica, and it seems almost certain that at least some well-drained soils with hardpan have always been well drained but have never had very high pH values. For this reason, the processes by which these pans have formed are not known.

Soils that have the most strongly developed hardpan are those that have a strongly developed textural B horizon or those, such as the Ayres soils, that formed mainly from material other than pumice but were covered by a layer of pumice, which can be a ready source of siliceous material. Imperfectly drained soils with hardpan, such as the Crooked and Forester soils, have high pH values. In these soils the configuration of the cementing material does not suggest that the material moved downward, and the pans may have been formed by the precipitation of siliceous material from ground water at the level of the water table.

Consistence and structure

In well-drained soils of the Prineville Area, the consistence and structure in the A horizon differ strikingly from those of some soils in other areas that have an A horizon of comparable texture and organic-matter content. The soft consistence and platy structure in soils of the Area likely are related to the nature and distribution of the organic matter and to the processes of freezing and thawing and of wetting and drying.

Calcium carbonate and base saturation

Leaching has been active in soils of the Area, as indicated by the absence of calcium carbonate and less than complete base saturation in the upper horizons. That leaching is far from complete, however, is shown by the presence of lime and fairly high base saturation in the lower horizons. Precipitation falls mostly in winter in this Area and, consequently, the depth of leaching is greater than the average annual precipitation might indicate. In general, Chestnut soils are more strongly leached than Brown soils.

Sodium saturation

Only the soils with a high water table have high sodium saturation. The sodium probably is supplied from the ground water and is exchanged for other cations in these soils.

Classification of Soils

Soil classification is intended to help us understand relationships and remember characteristics. The system used to classify the soils in the Prineville Area is explained in the U.S. Department of Agriculture Yearbook for 1938 (*15*). Since that year, our knowledge of the soils has increased and, as a result, a few changes have been made in the system.

In the 1938 system of soil classification, soils are placed in four categories. From the broadest category to the narrowest, these are the order, great soil group, series, and type.

Soils in the broadest category are classified in three soil orders—zonal, intrazonal, and azonal. Each of these orders consists of a number of great soil groups, only some of which are represented in this Area. The section "How Soils Are Mapped and Classified" describes how soils are classified in the lower categories—the soil series and soil type.

The classification of the soils in the Prineville Area by orders and great soil groups is discussed in this subsection and is shown in table 10.

TABLE 10.—*Classification of soil series by orders and great soil groups*

Great soil group and series	Remarks
ZONAL	
Brown soils:	
Ayres, Lamonta, Lookout, Ochoco.	Textural B horizon; hardpan.
Agency, Bakeoven, Redmond, Searles.	Textural B horizon; no hardpan.
Prineville	No textural B horizon; hardpan.
Courtrock, Deschutes	No textural B horizon; no hardpan.
Chestnut soils:	
Salisbury	Textural B horizon; hardpan.
Elmore, Gem, Polly	Textural B horizon; no hardpan.
INTRAZONAL	
Humic Gley soils:	
Boyce.	
Ontko.	
Soloth soils:	
Swartz.	
Solonetz soils:	
Stearns.	
Grumusols:	
Day.	
AZONAL	
Regosols:	
Steiger.	
Lithosols:	
Slayton.	
Alluvial soils:	
Crooked, Forester	Strongly sodic.
Metolius, Powder, Veazie	Typical.

Zonal soils

Zonal soils have developed through soil-forming processes dominated by climate and vegetation. In the Prineville Area the great soil groups in the zonal order are the Brown soils and the Chestnut soils.

BROWN SOILS

Brown soils have a surface horizon that is platy, soft or slightly hard, and light brownish gray or lighter when dry. These soils developed under bluebunch wheatgrass, Sandberg bluegrass, big sagebrush, and other native plants in a semiarid climate (*14*). Base saturation is high, and calcium carbonate is common in the lower horizons. A B horizon is present, but it may be weakly developed. Some of the Brown soils have a hardpan below the B horizon.

The Brown great soil group can be divided into four subgroups on the basis of the presence or absence of a textural B horizon and of a hardpan. In the first subgroup are soils that have a moderately or strongly developed textural B horizon and a strongly developed hardpan. Soils in this subgroup are the Ayres, Lamonta, Lookout, and Ochoco soils. The Ochoco sandy loam described in the subsection "Description of Soil Profiles" is typical of Brown soils that have a hardpan.

The second subgroup consists of soils that have a textural B horizon but have no hardpan or only an intermittent or weakly developed one. Soils in this subgroup are the Agency, Bakeoven, Redmond, and Searles soils.

In soils of the third and fourth subgroups, a textural B horizon is missing or is only weakly developed. These soils, however, have a horizon that resembles a textural B horizon but has little or no discernable accumulation of clay. In the third subgroup are the Prineville soils, which have a hardpan. In the fourth subgroup are the Courtrock and Deschutes soils, which do not have a hardpan. The soils of the third and fourth subgroups have some characteristics of Regosols.

CHESTNUT SOILS

Chestnut soils have a surface horizon that is platy, grayish brown, and soft or slightly hard when dry, and very dark grayish brown or darker when moist. These soils developed under a dense stand of bluebunch wheatgrass and a lesser amount of Sandberg bluegrass, Idaho fescue, big sagebrush, and bitterbrush. Rainfall is slightly higher than in areas of Brown soils.

In the Prineville Area the Chestnut soils are the Salisbury, Elmore, Gem, and Polly soils. These soils have a textural B horizon, and only the Salisbury soils have a hardpan. In general, base saturation is not quite so high in Chestnut soils as it is in Brown soils. In places lime occurs in the lower horizons. The Elmore soil described in the subsection "Descriptions of Soil Profiles" is typical of Chestnut soils.

Intrazonal soils

Intrazonal soils have developed through soil-forming processes dominated by relief or parent material. In this Area the great soil groups in the intrazonal order are the Humic Gley soils, the Soloth soils, the Solonetz soils, and the Grumusols.

HUMIC GLEY SOILS

Humic Gley soils have a dark-colored surface horizon and gray or mottled lower horizons. They are naturally wet, and wet conditions have dominated in their development. In the Prineville Area the Humic Gley soils are in the Boyce and Ontko series.

SOLOTH SOILS

Soloth soils have a thin, light-colored surface horizon over a gray, leached horizon that overlies darker, finer textured horizons. These soils formed under shrubs, grasses, or mixed grasses and trees, mainly in a semiarid or subhumid climate. They are naturally wet during part of the year. In the Prineville Area the only Soloth soils are in the Swartz series. The Swartz soils have an A1, an A2, and a textural B horizon. Laboratory analysis of their clay content shows that they grade toward the Planosol great soil group, but their content of exchangeable sodium and magnesium indicates that they are best classified as Soloth soils.

SOLONETZ SOILS

Solonetz soils have a friable surface horizon of variable thickness that is underlain by a textural B horizon of prismatic or columnar structure. These soils ordinarily contain a high percentage of sodium. They formed under grasses or shrubs, mainly in a subhumid or semiarid climate. In this Area the only Solonetz soils are in the Stearns series. The Stearns soils have a hardpan.

GRUMUSOLS

Grumusols are soils that have a fairly high content of clay and are marked by signs of local soil movement resulting from shrinking and swelling as the soils wet and dry. The horizons are churned or mixed because material from the upper horizons falls into deep, wide cracks when the soils are dry and, when they again are wet, material from the lower horizons is pushed upward as the cracks close. In this Area the Day soils show the effects of churning and are classified as Grumusols.

Azonal soils

Azonal soils have no development, or only weak development, of a profile, mainly because they are young soils. In the Prineville Area the great soil groups in the azonal order are Regosols, Lithosols, and Alluvial soils.

REGOSOLS

Regosols have a weakly developed A horizon but have no B or hardpan horizon. They developed from unconsolidated material other than recent alluvium. In this Area the only Regosols are in the Steiger series. If the definition of Regosols were broadened to include soils with hardpan, the Prineville soils could be classified Regosols rather than Brown soils.

LITHOSOLS

Lithosols have no clearly expressed soil morphology and consist of a freshly and imperfectly weathered mass of rock fragments. In most places they are shallow to bedrock. The Slayton soils are the only Lithosols in the Prineville Area.

ALLUVIAL SOILS

Alluvial soils consist of transported and recently deposited material. They are characterized by a weak modification, or no modification, of the original material by soil-forming processes. This great soil group is represented in the Prineville Area by the Metolius, Powder, Veazie, Crooked, and Forester soils.

The Metolius, Powder, and Veazie soils are typical Alluvial soils that are not strongly sodic and have a weakly developed A horizon over undifferentiated alluvial material.

The Crooked and Forester soils are strongly affected by alkali and have features more strongly expressed than typical. This is especially true of the Crooked soils, which have a hardpan. Nevertheless, the soils in these two series are classified as Alluvial soils.

Descriptions of Soil Profiles

Following are detailed descriptions of representative profiles of the different soil series in the Prineville Area. Soils having a profile number (for example, No. S55-Oreg.-7-3) are those for which laboratory data are given in the table that begins on p. 78.

Technical terms used in describing the soils are defined in the Soil Survey Manual (*13*); some of these terms also are defined in the Glossary at the end of this report. Letters and numerals on the left designate the horizons in each profile. Combinations of letters and numbers in parentheses, such as (10YR 5/4), are Munsell notations of hue, value, and chroma. These notations are more precise than descriptive names of color, which also are given.

AGENCY SERIES

Profile of Agency very stony sandy loam under native vegetation, located in the SE¼SW¼SW¼ sec. 6, T. 15 S., R. 16 E.:

A1—0 to 6 inches, grayish-brown (10YR 5/2) very stony sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, very fine, granular and weak, thin, platy structure; soft or slightly hard when dry, friable when moist, very slightly sticky and nonplastic when wet; roots common; many fine pores; neutral (pH 6.8); clear, wavy boundary.

A3—6 to 11 inches, light brownish-gray (10YR 6/2) very stony sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, subangular blocky structure crushing to weak, very fine, granular structure; soft or slightly hard when dry, friable when moist, very slightly sticky and nonplastic when wet; roots common; fine and medium pores are common; neutral (pH 7.0); clear, wavy boundary.

B1t—11 to 15 inches, pale-brown (10YR 6/3) very stony loam or light clay loam, dark brown (10YR 4/3) when moist; weak to moderate, medium and fine, blocky structure; hard when dry, firm when moist, sticky and slightly plastic when wet; common, fine and medium, tubular pores; few to common roots; thin, patchy clay films; neutral or mildly alkaline (ph 7.3 to 7.6); clear, wavy boundary.

B2t—15 to 22 inches, brown (10YR 5/3) very stony clay loam, dark brown (10YR 3/3) when moist; moderate, medium and fine, blocky structure; hard when dry, firm when moist, sticky and plastic when wet; common roots; few, fine and medium, tubular pores; moderately thick, continuous clay films on peds and in pores; moderate number of basalt fragments, rounded pebbles, and cobbles; calcareous in lower part; mildly alkaline (pH 7.6 to 8.0); gradual to clear, wavy boundary.

C1ca—22 to 36 inches, light brownish-gray (10YR 6/2) very gravelly and stony sandy loam to sandy clay loam, dark grayish brown (10YR 4/2) when moist; massive (structureless); slightly hard or hard when dry, firm when moist, slightly sticky and very slightly plastic when wet; few roots; few, fine, discontinuous, tubular pores; moderately alkaline (pH 8.2); calcareous; clear to gradual boundary.

IIC—36 inches +, light brownish-gray (10YR 6/2), poorly sorted, stratified sand, gravel, and stones that grade to sandstone or basalt.

AYRES SERIES

Profile of Ayres gravelly sandy loam (profile No. S55-Oreg.-7-3), located in the SE¼SE¼SE¼ sec. 19, T. 15 S., R. 15 E.:

A1—0 to 5 inches, light brownish-gray (10YR 6/2) gravelly sandy loam, dark grayish brown (10YR 4/2) when moist; weak, thin, platy structure breaking to weak, fine, granular structure or single grain; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; abundant roots; porous; moderate content of pale-brown pumice sand ranging from fine to medium in size; numerous grayish and reddish, angular and subangular pebbles; neutral (pH 6.8); clear, wavy boundary.

A3—5 to 8 inches, light brownish-gray (10YR 6/2) gravelly fine sandy loam, dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; soft or slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; abundant roots; moderately porous; the pebbles increase in number and size with depth; moderate to low pumice content; neutral (pH 6.8); clear, irregular boundary.

B2t—8 to 14 inches, brown (10YR 5/3) gravelly clay loam, dark brown (10YR 4/3) when moist; weak, medium, prismatic structure breaking to moderate, fine, subangular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; roots concentrated between peds; few pores; many channery fragments that are partly oriented and have flat surfaces generally horizontal; thin, nearly continuous, slightly darker clay films on peds; little or no pumice; calcium carbonate on lower surface of cobbles; neutral (pH 7.1); abrupt boundary.

C1sim—14 to 29 inches, pale-brown (10YR 6/3) gravelly and cobbly, indurated hardpan; lenses of brown silica appearing very dense, glazed, and opalized; carbonates on the lower side of cobbles; neutral.

C2—29 to 50 inches +, light brownish-gray (10YR 6/2), stratified very gravelly and cobbly loam or sandy loam that contains reddish and grayish pebbles and cobbles of rhyolite or dacite; massive (structureless); lime in seams.

BAKEOVEN SERIES

Profile of Bakeoven very stony loam, 0 to 20 percent slopes, in a range area located in the SE¼SE¼SE¼ sec. 7, T. 15 S., R. 15 E.:

A1—0 to 4 inches, grayish-brown (10YR 5/2) very stony loam, very dark grayish-brown (10YR 3/2) when moist; moderate, thin, platy structure crushing to weak, fine, granular structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; few to common roots; common, fine, tubular pores in lower 3 inches and many, fine, vesicular pores in upper 1 inch; silt films in vesicles; common, large, basaltic stones throughout this horizon; neutral (pH 6.8); clear, smooth boundary.

B1t—4 to 7 inches, pale-brown (10YR 6/3) very stony light clay loam or heavy loam, dark brown (10YR 4/3) when moist; weak to moderate, medium, platy structure and weak, fine and medium, subangular blocky structure; slightly hard when dry, friable or firm when moist, slightly sticky and slightly plastic when wet; few to common roots; common, fine, tubular pores; thin, patchy clay films along plates and in pores; neutral (pH 6.8); clear, wavy boundary.

B2t—7 to 11 inches, brown (10YR 5/3) very stony clay loam, dark brown (10YR 4/3) when moist; moderate, fine, subangular blocky structure; slightly hard when dry, firm when moist, sticky and plastic when wet; few roots; few, fine, tubular pores; thin, nearly continuous clay films on peds and in pores; neutral (pH 6.8-7.0); abrupt boundary.

R—11 inches +, very dark gray to black, vesicular basalt; commonly lime coated.

BOYCE SERIES

Profile of Boyce silty clay loam under sod, located in the NE¼SW¼ sec. 5, T. 15 S., R. 16 E.:

A11—0 to 3 inches, pale-brown (10YR 6/3) silty clay loam, yellowish brown (10YR 5/4) when moist; moderate, medium, granular structure grading to weak, thin, platy structure; slightly hard when dry, friable when moist, sticky and slightly plastic when wet; matted and bound with peaty roots; porous; moderately alkaline; moderately calcareous; abrupt, smooth boundary.

A12g—3 to 7 inches, grayish-brown to gray (2.5Y 5/2 to 5/1) silty clay loam, very dark grayish brown (10YR 3/2) when moist; common, fine and medium, distinct mottles of reddish brown; few, large, distinct areas mottled with dark gray and dark olive gray; moderate, very thin and medium, platy structure; hard when dry, friable when moist, sticky and plastic when wet; abundant roots; common, fine, tubular pores; moderately alkaline (pH 8.0–8.2); moderately calcareous; abrupt, wavy boundary.

A13g—7 to 10 inches, grayish-brown (10YR 5/2) silty clay loam, black (10YR 2/1) when moist; slightly finer in texture than above, with less organic matter and fewer roots; moderate, medium and fine, blocky structure; hard when dry, friable when moist, sticky and plastic when wet; plentiful roots; few, fine, tubular pores; few, dark-gray mottles; moderately alkaline; moderately calcareous; clear, smooth boundary.

AC1g—10 to 15 inches, grayish-brown (10YR 5/2) clay loam, very dark gray (10YR 3/1) when moist; moderate, fine and medium, blocky structure; hard when dry, friable when moist, sticky and plastic when wet; distinctly mottled with common, fine, reddish-brown and yellowish-brown stains and few, distinct, coarse bluish-gray or very dark gray splotches; few roots; few pores and root channels; moderately alkaline; calcareous; clear, smooth boundary.

AC2—15 to 24 inches, grayish-brown (2.5Y 5/2) clay loam, very dark grayish brown (10YR 3/2) when moist; massive (structureless) to weak, fine and medium, angular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; few, large, mottled bands or streaks of very dark gray; few roots; very few pores; mildly alkaline; noncalcareous; abrupt, smooth boundary.

C—24 to 31 inches, gray (2.5Y 5/0) sandy loam and sandy clay loam, very dark gray (2.5Y 3/1) when moist; massive (structureless); slightly hard when dry, friable when moist, slightly sticky and nonplastic when wet; few roots; porous; numerous worm casts or old root channels filled with material high in content of silt; noncalcareous; mildly alkaline; gradual to abrupt transition to lower strata of gravelly and sandy alluvium.

IIC2—31 inches +, stratified layers of sand and gravel.

COURTROCK SERIES

Profile of Courtrock sandy loam in a cultivated field located in the NE¼SW¼SW¼ sec. 34, T. 14 S., R. 16 E.:

Ap—0 to 8 inches, light brownish-gray (10YR 6/2) sandy loam, dark grayish-brown (10YR 4/2) when moist; weak, thin, platy structure breaking to weak, fine, granular structure; soft when dry, friable when moist, slightly sticky and nonplastic when wet; abundant roots; porous; upper one-half inch has common, fine vesicules or pores, a moderate amount of pale-brown, fine to coarse pumice sand and few to common, reddish pebbles; neutral (pH 6.8); clear, smooth boundary.

B1—8 to 16 inches, light brownish-gray (10YR 6/2) sandy loam, dark brown (10YR 4/3) when moist; weak, thin and medium, platy structure breaking to weak, fine, granular structure; soft or slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; plentiful roots; common, fine, tubular pores; few to common, reddish pebbles; moderate amount of pale-brown, fine and medium pumice sand; neutral (pH 6.9); clear, irregular boundary.

B21—16 to 21 inches, pale-brown (10YR 6/3) heavy sandy loam, dark brown (10YR 4/3) when moist; weak, medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; plentiful roots; many fine pores; small amount of pumice; neutral; clear to abrupt, wavy boundary.

B22—21 to 30 inches, brown (7.5YR 5/4) heavy sandy loam, dark brown (7.5YR 3/3) when moist; weak, fine and medium, blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; plentiful roots; many fine pores; an occasional clay film on peds; little pumice; calcium carbonate on under side of pebbles where gravel occurs; mildly alkaline (pH 7.8), mildly calcareous in lower part; clear, irregular boundary.

C1ca—30 to 37 inches, light-brown (7.5YR 6/4) fine gravelly sandy loam or fine gravelly loam, dark brown (7.5YR 3/3) when moist; weak, medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; plentiful roots; common fine pores; moderately alkaline; calcareous; clear, irregular boundary.

C2ca—37 to 50 inches, light-brown (7.5YR 6/3) fine gravelly heavy sandy loam, dark brown (7.5YR 3/3) when moist; massive (structureless); soft or slightly hard when dry, friable or firm when moist, slightly sticky and slightly plastic when wet; much calcium carbonate accumulated but segregated; moderately alkaline; gradual to abrupt boundary.

C3ca—50 to 60 inches, light yellowish-brown (10YR 6/4), stratified sandy loam or gravelly sandy loam, dark yellowish brown (10YR 4/4) when moist; massive (structureless); slightly hard when dry, friable when moist, slightly sticky and nonplastic when wet; moderately alkaline (pH 8.2); weakly to moderately calcareous.

CROOKED SERIES

Profile of Crooked sandy loam (profile No. S55–Oreg.–7–11), located in the NW¼SE¼SW¼ sec. 5, T. 15 S., R. 16 E. (1,600 feet east and 800 feet north of section corner):

Ap—0 to 6 inches, light brownish-gray (10YR 6/2) sandy loam, dark grayish brown (10YR 4/2) when moist; weak, thin and medium, platy structure breaking to weak, fine, granular structure; soft when dry, friable when moist, slightly sticky and nonplastic when wet; plentiful roots; pores mainly interstitial; slightly calcareous; pH 9.1; gradual, smooth boundary.

AC—6 to 13 inches, light brownish-gray (10YR 6/2) fine sandy loam, dark grayish brown (10YR 4/2) when moist; very weak, medium, subangular blocky structure; soft when dry, friable when moist, slightly sticky and nonplastic when wet; plentiful roots; pores mainly interstitial; moderately calcareous with disseminated lime; pH 9.0 to 10.0; abrupt boundary.

C1m—13 to 20 inches, light-gray (10YR 7/2), strongly cemented, thick platy hardpan, dark grayish brown (10YR 4/2) when moist; roots matted on top of the pan; moderately calcareous; pH 8.9; gradual boundary.

C2m—20 to 33 inches, pale-brown (10YR 6/3), thick platy hardpan, dark brown (10YR 4/3) when moist; cemented weakly to strongly but not so strongly as horizon above; moderately calcareous; pH 8.1; gradual boundary.

C3—33 to 60 inches, light brownish-gray (10YR 6/2), stratified fine and very fine sandy loam, dark grayish brown (10YR 4/2) when moist; massive (structureless); slightly hard when dry, firm or friable when moist, slightly sticky and slightly plastic when wet; no roots; few to common fine pores; moderately calcareous; pH 8.8.

DAY SERIES

Profile of Day clay in a range area located in the SE¼SE¼SE¼ sec. 6, T. 14 S., R. 16 E. (about 300 feet north of house and 150 feet west of section line):

A1—0 to 3 inches, reddish-brown (2.5YR 4/3) clay, dark reddish brown (10YR 3/4) when moist; strong, fine, granular structure; very hard when dry, friable when moist, very sticky and very plastic when wet; many to few roots; few pores; neutral (pH 6.8); abrupt boundary.

AC—3 to 19 inches, reddish-brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) when moist; moderate to strong, coarse, prismatic structure breaking to strong, medium, blocky structure; glazing on vertical sides of peds; very hard when dry, firm when moist, very sticky and very plastic when wet; few large roots concentrated between vertical surfaces of peds; few pores; neutral (pH 6.9); clear boundary.

C1—19 to 31 inches, dark reddish-brown (2.5YR 3/3 dry, 2.5YR 3/4 moist) clay; moderate to strong, medium, blocky structure; hard when dry, firm when moist, very sticky and very plastic when wet; few roots; few fine pores; few chips of segregated lime; mildly alkaline (pH 7.4); clear boundary.

C2ca—31 to 55 inches, weak-red (10R 4/3 dry, 10R 4/4 moist) clay; weak, very thick, platy structure; very hard when dry, very firm when moist, very sticky and very plastic when wet; very few roots; few fine pores; few seams of soft, segregated and discontinuous lime; neutral (pH 7.3); clear boundary.

C3—55 to 96 inches, weak-red (10R 4/3) clay, dusky red (10R 3/3) when moist; laminated; very hard when dry, the hardness increasing with depth; no roots; few or no pores; slightly calcareous; common, distinct manganese-dioxide stains; mildly alkaline; many feet thick.

DESCHUTES SERIES

Profile of Deschutes sandy loam in a range area located in the NE¼NW¼SW¼ sec. 6, T. 16 S., R. 14 E.:

A1—0 to 4 inches, light brownish-gray (10R 6/2) sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, medium to coarse, platy structure breaking to very weak, fine, granular structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; plentiful roots; pores mainly interstitial; mostly pumiceous material; neutral; clear, smooth boundary.

A3—4 to 11 inches, light brownish-gray (10YR 6/2) sandy loam, dark brown (10YR 3/3) when moist; weak, coarse, subangular blocky structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; plentiful roots; pores mainly interstitial but a few, medium, tubular pores; mostly pumiceous material; neutral; clear, smooth boundary.

B2—11 to 15 inches, pale-brown (10YR 6/3) sandy loam, dark brown (10YR 3/3) when moist; weak, subangular blocky structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; some roots; pores mainly interstitial; mostly pumiceous material; neutral; abrupt, irregular boundary.

IIC1—15 to 23 inches, pale-brown (10YR 6/3) light loam or fine sandy loam, dark brown (10YR 4/3) when moist; massive (structureless); hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few roots; many fine and few medium tubular pores; small amounts of pumice, few basaltic pebbles and cobbles; neutral or mildly alkaline; abrupt, wavy boundary.

IIIR—23 inches +, basalt bedrock, silica coated in some places and lime coated in others.

ELMORE SERIES

Profile of Elmore very stony loam (profile No. S55-Oreg.-7-5), located in the SE¼NW¼SE¼ sec. 9, T. 16 S., R. 15 E.:

A1—0 to 5 inches, grayish-brown (10YR 5/2) very stony loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; soft or slightly hard when dry, friable when moist, sticky and slightly plastic when wet; root mat or sodbound in uppermost part of horizon; common interstitial pores; some pumice; slightly acid (pH 6.3); gradual, irregular boundary.

A3—5 to 9 inches, grayish-brown (10YR 5/2) very stony loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, platy and weak, medium, subangular blocky structure; slightly hard when dry, friable when moist, sticky and slightly plastic when wet; numerous roots; many medium pores; subangular pebbles, cobbles, channery fragments, their number increasing with depth; slightly acid (pH 6.3); clear, irregular boundary.

B1t—9 to 14 inches, dark-brown (10YR 4/3) very stony heavy loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, prismatic structure breaking to weak, medium and fine, subangular blocky structure; slightly hard when dry, firm when moist, sticky and plastic when wet; common roots; common, fine, tubular pores; thin, patchy clay films; slightly acid (pH 6.4); clear, smooth boundary.

B21t—14 to 23 inches, dark-brown (10YR 4/3) very stony light clay loam, dark brown (10YR 3/3) when moist; moderate, medium, prismatic structure breaking to moderate, fine and medium, blocky structure; hard when dry, firm when moist, sticky and plastic when wet; common roots; common, fine, tubular pores; thin, continuous clay films on vertical peds and in pores; some lime on lower surface of rhyolite fragments; neutral (pH 7.0); gradual, smooth boundary.

B22t—23 to 35 inches, dark-brown (10YR 4/3) very channery light clay loam, dark brown (10YR 3/3) when moist; moderate, medium and fine, blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; few large roots; few, fine, tubular pores; common, patchy, thin clay films on ped surfaces and in pores; slightly acid (pH 6.5); lime occurs on lower surface of cobbles; gradual, smooth boundary.

B23t—35 to 50 inches, dark-brown (10YR 4/3) very channery clay loam; weak, medium and fine, angular and subangular blocky structure; slightly hard when dry, firm when moist, sticky and plastic when wet; few roots; few, fine, tubular pores; few, thin, patchy clay films on ped faces and in pores; mildly alkaline (pH 7.4); slightly calcareous, mainly in seams and fine nodules; abrupt boundary.

R—50 inches +, rhyolite bedrock.

FORESTER SERIES

Profile of Forester loamy sand in a cultivated field located in the NW¼SE¼SW¼ sec. 6, T. 15 S., R. 16 E.:

Ap—0 to 7 inches, light brownish-gray (10YR 6/2) loamy sand, dark grayish brown (10YR 4/2) when moist; weak, thin, platy structure crushing to single grain (structureless); soft when dry, very friable when moist, nonsticky and nonplastic when wet; plentiful roots; pores mainly interstitial; pH 9.0 to 9.5; moderately calcareous, clear, smooth boundary.

AC—7 to 12 inches, light brownish-gray (10YR 6/2) loamy sand, dark grayish brown (10YR 4/2) when moist; weak, fine, subangular blocky structure crushing to single grain (structureless); soft when dry, very friable when moist, nonsticky and nonplastic when wet; plentiful roots; pores mainly interstitial; pH 9.0 to 9.6; strongly calcareous; gradual boundary.

C1—12 to 22 inches, pale-brown (10YR 6/3) loamy sand, dark brown (10YR 4/3) when moist; massive; soft when dry, very friable when moist, nonplastic and nonsticky when wet; plentiful roots; pores mainly interstitial; few, slightly hard concretions ½ to ¾ inch in diameter; pH 8.6 to 9.6; strongly calcareous; clear boundary.

C2—22 to 27 inches, pale-brown (10YR 6/3) loamy sand, dark brown (10YR 4/3) when moist; massive; soft when dry, very friable when moist, nonplastic and nonsticky when wet; few roots; pores mainly interstitial; pH 8.6 to 9.6; strongly calcareous; clear to abrupt boundary.

IIC3—27 to 48 inches, pale-brown (10YR 6/3) very fine sandy loam, dark brown (10YR 4/3) when moist; massive to weak platy structure; slightly hard or hard when dry, friable but slightly brittle when moist, slightly sticky and slightly plastic when wet; few, fine, tubular pores; pH 8.5 to 9.0; moderately calcareous; clear, wavy boundary.

IIC4—48 inches +, pale-brown (10YR 6/3), stratified silt loam, fine sandy loam, and loam, dark brown (10YR 4/3) when moist; massive; slightly hard or hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few roots; few root channels; pH 8.5 to 9.0; moderately calcareous.

GEM SERIES

Profile of Gem very stony loam in a range area located in the SE¼SE¼SE¼ sec. 31, T. 14 S., R. 18 E. (400 feet north and 600 feet west of section corner):

A1—0 to 5 inches, grayish-brown (10YR 5/2) very stony loam, very dark brown (10YR 2/2) when moist; moderate, fine, granular and weak, thin, platy structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; numerous roots; porous; slightly acid or neutral (pH 6.5 to 6.8); clear, wavy boundary.

A3—5 to 9 inches, grayish-brown (10YR 5/2) very stony loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium to fine, blocky structure crushing to fine, granular structure; hard when dry, friable or firm when moist, slightly sticky and slightly plastic when wet; common roots; porous; neutral (pH 6.8); clear, wavy boundary.

B1t—9 to 13 inches, brown (10YR 5/3) very stony light clay loam or heavy loam, dark brown (10YR 3/3) when moist; weak, medium, prismatic and moderate, medium, blocky structure breaking to weak, fine, blocky structure; hard when dry, firm or friable when moist, slightly sticky and slightly plastic when wet; thin, patchy clay films on peds and in pores; common roots and root channels; neutral (pH 6.9 to 7.0); abrupt, wavy boundary.

B21t—13 to 20 inches, dark-brown (10YR 4/3) stony clay loam, dark brown (10YR 3/3) when moist; moderate, medium, prismatic structure breaking to moderate and strong, medium, blocky structure; hard when dry, firm when moist, sticky and plastic when wet; roots concentrated along vertical surface of peds; moderately thick, very dark grayish-brown, continuous clay films on ped surfaces; neutral (pH 7.0 to 7.2); clear, smooth boundary.

B22t—20 to 26 inches, dark-brown (10YR 4/3) stony heavy clay loam, dark yellowish brown (10YR 3/4) when moist; moderate, medium, prismatic structure crushing to strong, fine and medium, blocky structure; hard when dry, firm when moist, sticky and plastic when wet; few pores; roots concentrated between peds; thick, very dark grayish-brown, continuous clay films on surface of peds; moderately alkaline (pH 8.0); calcareous; clear, wavy boundary.

B3tca—26 to 28 inches, light yellowish-brown (10YR 6/4) very stony clay loam, yellowish brown (10YR 5/4) when moist; moderate, medium, blocky structure; hard when dry, firm when moist, sticky and plastic when wet; few roots; few pores; thin, continuous clay films on peds and in pores; moderately alkaline (pH 8.2); calcareous; abrupt to clear, wavy boundary.

R—28 inches +, lime-coated basalt fragments and basalt bedrock.

LAMONTA SERIES

Profile of Lamonta gravelly loam (profile No. S55-Oreg.-7-13), located in the NW¼NE¼SW¼ sec. 32, T. 13 S., R. 15 E.:

Ap—0 to 7 inches, light brownish-gray (10YR 6/2) gravelly loam, very dark grayish brown (10YR 3/2) when moist; weak, thin, platy structure breaking to weak, fine, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; abundant roots; pores mainly interstitial; small amount of pale-brown pumice and numerous small, reddish, angular and subangular pebbles; neutral (pH 6.8); clear boundary.

B1—7 to 9 inches, brown (10YR 5/3) gravelly clay loam, dark grayish brown (10YR 3/2) when moist; moderate, medium and fine, blocky structure; hard when dry, firm when moist, sticky and plastic when wet; plentiful roots; many, fine, tubular pores; thin, patchy clay films; rhyolite pebbles larger than in horizon above; slightly acid (pH 6.5); abrupt, wavy boundary.

B21t—9 to 20 inches, brown (10YR 5/3) clay, dark brown (10YR 3/3) when moist; moderate to strong, medium, prismatic structure breaking to moderate, fine and medium, blocky structure; hard when dry, firm when moist, very sticky and very plastic when wet; thick, continuous clay films on vertical and horizontal surfaces of peds; few to no pores; roots oriented between ped surfaces; mixed gravel increases in size with depth; neutral (pH 7.1); clear, wavy boundary.

B22t—20 to 23 inches, brown or yellowish-brown (10YR 5/3 to 5/4) gravelly clay, dark yellowish brown (10YR 4/4) when moist; moderate, medium, blocky structure; hard when dry, firm when moist, sticky and plastic when wet; nearly continuous, thick clay films; mildly alkaline (pH 7.6); mildly calcareous; abrupt, smooth boundary.

Csim—23 to 36 inches +, pale-brown to light-gray (10YR 6/3 to 7/2), indurated, silica-cemented hardpan of gravelly loam or sandy loam; massive (structureless) to thick, platy structure; moderately alkaline (pH 8.2); thin, dense lenses of silica; lime in seams; common stains of manganese dioxide.

LOOKOUT SERIES

Profile of Lookout very stony loam in native range located in the NW¼NW¼SE¼ sec. 12, T. 15 S., R. 16 E.:

A1—0 to 8 inches, light brownish-gray (10YR 6/2) very stony loam, dark grayish brown (10YR 4/2) when moist; moderate, thin and medium, platy structure crushing to fine, granular structure; slightly hard when dry, friable when moist, sticky and plastic when wet; numerous roots and pores; top inch has many fine, vesicular pores; neutral (pH 6.7 to 6.8); clear, smooth to wavy boundary.

B1t—8 to 10 inches, grayish-brown (10YR 5/2) very stony light clay or heavy clay loam, very dark grayish brown (10YR 3/2) when moist; moderate to strong, medium, blocky structure; hard when dry, firm when moist, sticky and plastic when wet; numerous roots; less porous than horizon above; moderately thick, continuous clay films; neutral (pH 6.8); abrupt, wavy boundary.

B2t—10 to 18 inches, brown (10YR 5/3) very stony clay, dark brown to dark yellowish brown (10YR 3/3 to 3/4) when moist; strong, medium, prismatic structure breaking to strong, fine and medium, blocky structure; hard when dry, firm when moist, very sticky and very plastic when wet; few pores; roots concentrated along vertical surface of peds; distinct, thick, continuous, somewhat darker clay films and organic stains; neutral or mildly alkaline (pH 7.3 to 7.4); clear, irregular boundary.

B3tca—18 to 20 inches, yellowish-brown or light yellowish-brown (10YR 5/4 or 6/4) stony clay, dark brown (10YR 4/3) when moist; moderate, medium, blocky structure to strong, fine, blocky structure; hard when dry, firm when moist, sticky and plastic when wet; few pores; few roots; thick, continuous clay films; moderately alkaline (pH 7.8 to 8.0); calcareous; segregated lime; abrupt, irregular boundary.

Csim—20 to 30 inches, light yellowish-brown (10YR 6/4), strongly cemented hardpan, dark brown (10YR 4/3) when moist; moderately thick, platy structure; several dark-brown, ⅛-inch silica lenses; moderately alkaline (pH 8.3); strongly calcareous; abrupt boundary.

R—30 inches +, basaltic bedrock.

METOLIUS SERIES

Profile of Metolius sandy loam in a cultivated field located in the east half of SE¼NE¼NE¼ sec. 29, T. 16 S., R. 14 E.:

Ap—0 to 8 inches, light brownish-gray (10YR 6/2) sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; soft when dry, friable when moist, nonsticky and nonplastic when wet; abundant roots; pores mainly interstitial; neutral; clear, smooth boundary.

C1—8 to 18 inches, light brownish-gray (10YR 6/2) sandy loam, very dark grayish brown (10YR 3/2) when moist; massive (structureless); slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; plentiful roots; few, fine, tubular pores, but pores mainly interstitial; neutral; gradual, smooth boundary.

C2—18 to 42 inches, pale-brown (10YR 6/3) sandy loam, dark brown (10YR 3/3) when moist; massive; soft when dry, friable when moist, nonsticky and nonplastic when wet; plentiful roots; common, fine, tubular and interstitial pores; mildly alkaline; gradual, smooth boundary.

C3—42 to 60 inches +, light brownish-gray (10YR 6/2) sandy loam, dark brown (10YR 3/3) when moist; massive; soft when dry, friable when moist, nonsticky and nonplastic when wet; plentiful roots; common, fine, tubular and interstitial pores; mildly alkaline.

OCHOCO SERIES

Profile of Ochoco sandy loam (profile No. S55–Oreg.–7–15), located in the southwest quarter of SW¼NW¼SE¼ sec. 13, T. 14 S., R. 15 E.:

Ap—0 to 8 inches, light brownish-gray (10YR 6/2) sandy loam, dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; soft or slightly hard when dry; very friable when moist, slightly sticky when wet; abundant roots; many pores; some pumice sand; neutral (pH 7.3); clear, smooth boundary.

A3—8 to 16 inches, light brownish-gray (10YR 6/2) sandy loam, dark grayish brown (10YR 4/2) when moist; weak, medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; abundant roots; porous; neutral (pH 7.3); diffuse to clear boundary.

B1—16 to 21 inches, pale-brown (10YR 6/3) heavy fine sandy loam, dark brown (10YR 4/3) when moist; weak to moderate, medium, subangular blocky structure; slightly hard when dry, friable or firm when moist, slightly sticky and slightly plastic when wet; common roots; common, fine, tubular pores; thin, patchy clay films; neutral (pH 7.3); clear boundary.

B2t—21 to 28 inches, brown (10YR 5/3) sandy clay loam, dark brown (10YR 4/3) when moist; weak to moderate, medium, prismatic structure breaking to moderate, medium and fine, subangular blocky structure; hard when dry, firm when moist, sticky and slightly plastic when wet; common roots; common, fine, tubular pores; thin, nearly continuous clay films on peds and in pores; few, rounded basaltic pebbles; neutral (pH 7.3); clear boundary.

B3—28 to 36 inches, brown to yellowish-brown (10YR 5/3 to 5/4) gravelly sandy clay loam, dark brown to dark yellowish brown (10YR 4/3 to 4/4) when moist; weak, medium, prismatic structure breaking to moderate, medium and fine, subangular blocky structure; hard when dry, firm when moist, sticky and slightly plastic when wet; roots few; common, fine, tubular pores; thin, patchy clay films; seams of lime in many places; mildly alkaline (pH 7.4); clear to abrupt boundary.

C1mca—36 to 46 inches, pale-brown (10YR 6/3), weakly to strongly cemented pan, brown to dark brown (10YR 5/3 to 3/3) when moist; moderate, coarse, platy structure to massive; pan occurs in hard and soft lenses; roots penetrate pan with difficulty; root mat on top of pan; lime occurs as hard, segregated lenses or seams; moderately alkaline (pH 8.0); clear boundary.

C2ca—46 to 60 inches, light-gray to very dark grayish-brown (10YR 6/1 to 3/2) sand, sandy loam, or very gravelly loamy sand, very dark grayish brown to grayish brown (10YR 3/2 to 5/2) when moist; weakly consolidated and weakly calcareous; moderately alkaline (pH 8.1); most pebbles are basalt, but some are andesite and rhyolite.

ONTKO SERIES

Profile of Ontko clay loam in a cultivated meadow located in the NW¼NW¼NW¼ sec. 24, T. 14 S., R. 18 E.:

Ap—0 to 7 inches, black (10YR 2/1) clay loam, dark gray (10YR 4/1) when dry; weak to medium, thin, platy structure breaking to moderate, fine, granular structure; slightly hard when dry, firm when moist, sticky and plastic when wet; abundant roots; sod bound; pH 6.6; clear, smooth boundary.

A1—7 to 13 inches, clay loam, very dark gray (10YR 3/1) when moist; moderate, fine, subangular blocky structure; firm when moist, sticky and plastic when wet; plentiful roots; numerous, distinct, fine mottles of dark reddish brown and large mottles of dark olive; pH 6.7 to 7.2; gradual boundary.

AC—13 to 22 inches, clay loam, very dark gray to dark grayish brown (10YR 3/1 to 4/2) when moist; weak, fine to medium, subangular blocky structure; friable or firm when moist, sticky and plastic when wet; few roots; pH 6.7 to 7.0; gradual boundary.

C1—22 to 43 inches, stratified loam, sandy clay loam, coarse sandy loam, and loamy coarse sand, very dark gray to dark grayish brown (10YR 3/1 to 4/2) when moist; massive; soft to hard when dry, friable when moist, sticky to nonsticky and slightly plastic to nonplastic when wet; few roots; pH 6.4 to 7.0; abrupt boundary.

C2—43 inches +, stratified sandy loam, silt loam, and silty clay loam, very dark grayish brown to dark brown (10YR 3/2 to 4/3) when moist; common, fine, faint mottles; massive; friable or firm when moist, slightly sticky and slightly plastic when wet; pH 6.2 to 7.6.

POLLY SERIES

Profile of Polly gravelly loam in a range area located in the NW¼SE¼SE¼ sec. 22, T. 14 S., R. 17 E. (about 700 feet north of section corner and 20 feet west of Mill Creek Road):

A1—0 to 6 inches, dark-gray (10YR 4/1) gravelly loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; abundant roots; pH 6.7 to 7.0; clear, wavy boundary.

B1t—6 to 10 inches, grayish-brown (10YR 5/2) gravelly clay loam, very dark grayish brown (10YR 3/2) when moist; weak to moderate, medium, prismatic structure and moderate to strong, fine, blocky structure; hard when dry, friable when moist, plastic and very sticky when wet; plentiful roots; moderately thick, nearly continuous clay films on peds and in large pores; pH 6.8 to 7.0; abrupt, wavy boundary.

B2t—10 to 18 inches, reddish-brown (5YR 5/4) heavy clay loam, reddish brown (5YR 4/4) when moist; weak to moderate, medium, prismatic structure and moderate to strong, fine and very fine, blocky structure; hard when dry, firm when moist, very sticky and plastic when wet; few fine roots; very few pores; peds have thick, continuous clay films that are dark reddish brown when moist; slightly calcareous; small amount of segregated lime; pH 7.0 to 7.8; gradual, wavy boundary.

B3—18 to 27 inches, reddish-brown (5YR 5/4 dry, 5YR 4/4 moist) clay loam; weak, medium, prismatic structure and moderate, fine, blocky structure; hard when dry, firm or friable when moist, sticky and plastic when wet; few fine roots; very few pores; moderately thick, continuous clay films on peds; moderately calcareous; segregated lime; pH 7.6 to 8.2; gradual, wavy boundary.

C1ca—27 to 38 inches, yellowish-red (5YR 5/6) clay loam, reddish brown (5YR 4/4) when moist; massive; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; few roots; very few pores; strongly calcareous; pH 8.0 to 8.4; clear, wavy boundary.

C2—38 to 72 inches, brown (7.5YR 5/3) clay loam, dark brown (7.5YR 4/3) when moist; massive; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; no roots; very few pores; moderately to slightly calcareous; pH 7.8 to 8.2.

POWDER SERIES

Profile of Powder loam, located in the NW¼NW¼SW¼ sec. 8, T. 15 S., R. 16 E. (400 feet south and 600 feet east of the west quarter corner):

Ap—0 to 6 inches, grayish-brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) when moist; weak, thin and medium, platy structure crushing to weak, medium, granular structure; soft or slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; numerous roots; porous; little pumice; neutral (pH 7.0); clear, smooth boundary.

AC—6 to 13 inches, grayish-brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, subangular blocky structure; soft or slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; numerous roots and root channels; porous; little pumice; mildly alkaline (pH 7.5); clear, wavy boundary.

C1—13 to 25 inches, grayish-brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, subangular blocky structure crushing to medium, very fine, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common roots and root channels; moderately alkaline (pH 8.0); calcareous; clear, smooth boundary.

C2—25 to 31 inches, grayish-brown (10YR 5/2), stratified fine sandy loam and loam, dark grayish brown (10YR 4/2) when moist; weak, medium, subangular blocky structure to massive (structureless); soft when dry, friable when moist, slightly sticky and slightly plastic when wet; common roots; porous; calcareous; moderately alkaline (pH 8.2); clear to abrupt boundary.

C3—31 to 41 inches, gray (10YR 5/1) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, blocky structure crushing to moderate, very fine, blocky structure; slightly hard when dry, friable or firm when moist, sticky and slightly plastic when wet; common roots; numerous worm casts and root channels; few pores; moderately alkaline (pH 8.3); calcareous; abrupt, wavy boundary.

C4—41 to 48 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, coarse, platy structure to massive (structureless) crushing to moderate, fine and very fine, blocky structure; slightly hard when dry, firm when moist, slightly sticky and slightly plastic when wet; few roots and root channels; few pores; moderately alkaline (pH 8.2); calcareous; clear, smooth boundary.

C5—48 to 80 inches, light brownish-gray (10YR 6/2), stratified fine and very fine sandy loam, dark grayish brown (10YR 4/2) when moist; massive; soft when dry, friable when moist, slightly sticky and nonplastic when wet; few roots; porous; moderately alkaline (pH 8.2); calcareous.

PRINEVILLE SERIES

Profile of Prineville sandy loam (profile No. S55-Oreg.-7-18), located in the SE¼NW¼NE¼ sec. 8, T. 14 S., R. 15 E.:

Ap—0 to 9 inches, light brownish-gray (10YR 6/2) sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; soft when dry, friable when moist, nonsticky and nonplastic when wet; roots common; porous; moderate pumice content; neutral (pH 7.1); gradual, irregular boundary.

A3—9 to 16 inches, light brownish-gray (10YR 6/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, thick, platy structure crushing to weak, fine, subangular blocky structure; soft when dry, very friable when moist, slightly sticky and nonplastic when wet; roots common; mildly alkaline (pH 7.8); gradual boundary.

B2—16 to 20 inches, light brownish-gray (10YR 6/2) fine sandy loam, dark grayish brown (10YR 4/2) when moist; weak, medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and nonplastic when wet; common, fine roots; moderately alkaline (pH 8.2); clear, wavy boundary.

C1m—20 to 32 inches, pale-brown (10YR 6/3) very fine sandy loam, pale brown (10YR 5/3) when moist; weak, thick, platy structure breaking to moderate, medium and fine, subangular blocky structure; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; few roots; lenses are weakly cemented; few, hard, 1-inch nodules that are strongly calcareous; slightly calcareous matrix; strongly alkaline (pH 8.6); clear, wavy boundary.

C2m—32 to 47 inches, pale-brown (10YR 6/3) very fine sandy loam, dark grayish brown (10YR 4/2) when moist; moderate, thin to thick, platy structure; very hard when dry, very firm when moist; few root channels; lenses weakly cemented; thin lenses of hard, segregated lime; calcareous; strongly alkaline (pH 8.6); clear, wavy boundary.

C3—47 to 60 inches, light brownish-gray (10YR 6/2) gravelly loamy fine sand, dark grayish brown (10YR 4/2) when moist; massive (structureless); soft when dry, friable when moist; few, firm lenses of lime; strongly alkaline (pH 8.5); slightly calcareous; diffuse, gradual boundary to partially consolidated, pumiceous or tuffaceous sandstone or agglomerate.

REDMOND SERIES

Profile of Redmond sandy loam in range area located in the NW¼NW¼SE¼ sec. 10, T. 15 S., R. 14 E.:

A1—0 to 5 inches, grayish-brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; abundant roots; pores mainly interstitial; neutral; clear, smooth boundary.

A3—5 to 11 inches, grayish-brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, coarse, prismatic structure breaking to weak, fine, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; plentiful roots; many, fine, tubular pores; neutral; clear, smooth boundary.

B1t—11 to 19 inches, brown (10YR 5/3) heavy sandy loam, dark brown (10YR 3/3) when moist; weak, coarse, subangular blocky structure; soft when dry; friable when moist, slightly sticky and slightly plastic when wet; plentiful roots; common, fine, tubular pores; neutral or mildly alkaline; clear, smooth boundary.

B2t—19 to 25 inches, brown (10YR 5/3) loam or sandy clay loam, dark brown (10YR 3/3) when moist; weak, medium and coarse, subangular blocky structure; slightly hard when dry, friable when moist, sticky and slightly plastic when wet; plentiful roots; many, fine, tubular pores; neutral or mildly alkaline; clear, smooth boundary.

C1—25 to 30 inches, pale-brown (10YR 6/3) loam, dark brown (10YR 4/3) when moist; weak, medium, platy structure; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; plentiful roots; many, fine and few, medium, tubular pores; mildly alkaline; clear, smooth boundary.

C2ca—30 to 33 inches, light brownish-gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) when moist; massive (structureless) to weak, thick, platy structure; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; plentiful roots; many, fine, tubular pores; calcareous; mycelial lime; moderately alkaline; abrupt, wavy boundary.

IIR—33 inches +, basalt bedrock.

SALISBURY SERIES

Profile of Salisbury very stony loam in range area located in the southeast quarter of NW¼NE¼SE¼ sec. 14, T. 15 S., R. 16 E. (about 700 feet west and 400 feet south of the east quarter corner):

A1—0 to 4 inches, grayish-brown (10YR 5/2) very stony loam, very dark brown (10YR 2/2) when moist; moderate, thin and very thin, platy structure breaking to moderate, fine, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; abundant roots; many interstitial pores; pH 6.5 to 6.9; clear, smooth boundary.

A3—4 to 8 inches, grayish-brown (10YR 5/2) very stony gravelly clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium and fine, subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; abundant roots; common, fine, tubular pores; pH 6.7 to 7.0; clear, wavy boundary.

B1t—8 to 13 inches, brown (7.5YR 5/2) very stony heavy clay loam or gravelly light clay, dark brown (7.5YR 3/2) when moist; weak to moderate, medium, prismatic structure breaking to moderate or strong, fine and very fine, blocky structure; hard when dry, firm when moist, sticky and plastic when wet; plentiful roots; common, fine, tubular pores; moderately thick, continuous clay films on ped surfaces and in large pores; pH 6.7 to 7.2; clear, smooth boundary.

B2t—13 to 21 inches, dark-brown (7.5YR 4/3) very stony clay, dark brown (7.5YR 3/3) when moist; strong, medium, prismatic structure breaking to strong, fine and very fine, blocky structure; hard or very hard when dry, very firm when moist, very sticky and very plastic when wet; some roots; very few pores; thick, continuous clay films on ped surfaces and in pores; pH 6.7 to 7.5; abrupt, smooth boundary.

C1m—21 to 27 inches, light yellowish-brown (10YR 6/4), strongly cemented to indurated, gravelly hardpan, dark yellowish brown (10YR 4/4) when moist; no roots; calcareous; pH 7.0 to 8.2; gradual boundary.

C2m—27 to 38 inches, pale-brown (10YR 6/3), strongly cemented, gravelly hardpan, dark brown (10YR 4/3) when moist; no roots; calcareous; pH 8.0 to 8.4; abrupt boundary.

R—38 inches +, basalt bedrock.

SEARLES SERIES

Profile of Searles stony loam (profile No. S55–Oreg.–7–7) on a south-facing slope of 30 percent, located in SE¼SW¼NE¼ sec. 9, T. 16 S., R. 15 E.:

A1—0 to 3 inches, grayish-brown (10YR 5/2) stony loam, very dark grayish brown (10YR 3/2) when moist; weak, thin, platy structure breaking to weak, fine, granular structure; soft or slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; neutral (pH 6.8); clear, smooth boundary.

A3—3 to 8 inches, grayish-brown (10YR 5/2) stony loam, very dark brown to very dark grayish brown (10YR 2/2 to 3/2) when moist; weak, medium, platy structure breaking to weak, fine, subangular blocky structure; slightly hard when dry, friable when moist; slightly sticky and slightly plastic when wet; neutral (pH 6.8); clear, irregular boundary.

B21t—8 to 18 inches, brown to dark-brown (10YR 5/3 to 4/3) very gravelly or stony heavy loam or light clay loam, dark brown (10YR 3/3) when moist; weak to moderate, medium, prismatic structure breaking to moderate, medium and fine, angular and subangular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; neutral (pH 7.0); gradual, smooth boundary.

B22t—18 to 25 inches, brown (10YR 5/3) very stony or very gravelly heavy loam or light clay loam, dark brown (10YR 3/3) when moist; weak, medium and fine, blocky structure with very weak, vertical parting; hard when dry, firm when moist, sticky and plastic when wet; neutral (pH 7.3); lime on lower face of coarse fragments; gradual, smooth boundary.

C—25 to 40 inches, brown (10YR 5/3) very stony or very gravelly loam, brown (10YR 4/3) when moist; weak, medium, subangular blocky structure; hard when dry, friable or firm when moist, slightly sticky and plastic when wet; neutral (pH 7.2); 80 percent or more stones; lime on lower face of coarse fragments; clear to abrupt boundary.

R—40 inches +, banded gray, white, pink, and reddish rhyolite that, in places, is capped by 1 to 4 inches of strongly cemented to indurated lime and silica hardpan lenses.

SLAYTON SERIES

Profile of Slayton sandy loam in a range area located in the NW¼SW¼SE¼ sec. 22, T. 14 S., R. 16 E. (nearly opposite a large outcrop of rock in an adjacent cultivated field):

A1—0 to 4 inches, light brownish-gray (10YR 6/2) sandy loam, dark grayish brown (10YR 4/2) when moist; weak, thin, platy structure crushing to weak, fine, granular structure; soft when dry, very friable when moist, slightly sticky and nonplastic when wet; abundant roots; porous; numerous, small, pale-green chips and angular pebbles as well as some channery fragments of tuff on and in surface; moderate amounts of pale-brown, fine and medium-sized pumice sand; neutral (pH 6.6); irregular, clear boundary.

AC—4 to 8 inches, light brownish-gray (10YR 6/2) fine gravelly sandy loam, dark grayish brown (10YR 4/2) when moist; weak, medium, subangular blocky structure; soft when dry, very friable when moist, slightly sticky and nonplastic when wet; common roots; porous; small to moderate amount of pumice; few to many fine chips; neutral (pH 6.8); clear, wavy boundary.

C—8 to 14 inches, light brownish-gray (10YR 6/2) channery sandy loam, dark brown (10YR 4/3) when moist; weak, fine and medium, subangular blocky structure; soft when dry, very friable when moist, slightly sticky and nonplastic when wet; few roots; porous; mostly noncalcareous, but in places there are lime coatings on lower side of channery fragments; neutral (pH 7.0–7.2); abrupt boundary.

R—14 inches +, pale-green to light yellowish-green sandy tuff that fractures readily in the upper 2 or 3 inches into horizontal plates about 1 inch thick; fragments stained with manganese dioxide and lime in places.

STEARNS SERIES

Profile of Stearns silt loam (profile No. S55–Oreg.–7–10), located in the SE¼SE¼SW¼ sec. 19, T. 15 S., R. 16 E. (about 60 feet west of State Route 27 and 300 feet north of the section line):

A21—0 to 3 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; moderate, thin to very thin, platy structure; soft or slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; neutral (pH 6.8); clear boundary.

A22—3 to 5 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; moderate, medium and thin, platy structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; neutral (pH 7.3); abrupt boundary.

B2t—5 to 13 inches, brown (10YR 5/3) silty clay loam, dark brown (10YR 3/3) when moist; moderate to strong, medium, prismatic structure breaking to strong, fine, blocky structure; hard when dry, firm when moist, very sticky and very plastic when wet; moderately thick, continuous clay films on peds; organic stains on faces of prisms; calcareous; very strongly alkaline (pH 9.2); abrupt boundary.

C1m—13 to 22 inches, light brownish-gray (10YR 6/2) silt loam; massive (structureless) to weak, thick, platy structure; very hard or hard when dry, very firm when wet, slightly sticky and slightly plastic when wet; roots are restricted, but a few roots penetrate pan; weakly lime cemented; slightly calcareous; very strongly alkaline (pH 9.6); gradual boundary.

C2m—22 to 36 inches, light brownish-gray (10YR 6/2) silt loam, dark brown (10YR 3/3) when moist; massive; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; very few fine roots; many fine pores; very weakly lime cemented; strongly calcareous; very strongly alkaline (pH 9.2); clear boundary.

C3—36 to 48 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) when moist; somewhat stratified; massive; slightly hard when dry, friable or firm when moist, slightly sticky and slightly plastic when wet; slightly calcareous; strongly alkaline (pH 8.9).

C4—48 to 60 inches, pale brown (10YR 6/3), stratified fine sandy loam, very fine sandy loam, and silt loam, dark brown (10YR 4/3) when moist; slightly calcareous; strongly alkaline (pH 8.7).

STEIGER SERIES

Profile of Steiger sandy loam in a cultivated field located in the NE¼SE¼SW¼ sec. 4, T. 14 S., R. 19 E. (about 2,000 feet east and 1,300 feet north of the section corner):

Ap—0 to 7 inches, grayish-brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, thin, platy structure breaking to weak, fine, granular structure; soft or slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; abundant roots and root channels; porous; few basaltic pebbles; neutral (pH 6.6); abrupt boundary.

AC—7 to 14 inches, grayish-brown to pale-brown (10YR 5/2 to 6/3) sandy loam, higher in content of medium and fine pumice than horizon above, very dark grayish brown grading to dark brown (10YR 3/2 to 3/3) when moist; weak, medium and fine, subangular blocky structure crushing to weak, fine, granular structure; soft or slightly hard when dry, very friable when moist, slightly sticky and nonplastic when wet; numerous roots; porous; neutral (pH 6.8); clear, wavy boundary.

C1—14 to 22 inches, pale-brown (10YR 6/3) sandy loam, dark brown (10YR 3/3 to 4/3) when moist; moderate pumice content; weak, medium and fine, subangular blocky structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; roots common; numerous pores; neutral (pH 6.9 or 7.0); clear, irregular boundary.

C2—22 to 28 inches, brown (10YR 5/3) sandy loam, dark brown (10YR 4/3) when moist; massive (structureless) to weak, coarse, subangular blocky structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; few roots; porous; few, weakly calcareous, fine shot; mildly alkaline (pH 7.6); clear, irregular boundary.

C3—28 to 69 inches, pale-brown (10YR 6/3), stratified sandy loam and fine sandy loam, dark brown (10YR 3/3) when moist; massive, with pumice standing out as single grains; soft when dry, very friable when moist, slightly sticky and nonplastic when wet; few roots; porous; mildly alkaline (pH 7.5); gradual transition to more gravelly strata below.

SWARTZ SERIES

Profile of Swartz silt loam (profile No. S55–Oreg.–7–1), located in the SE¼SW¼SE¼ sec. 34, T. 14 S., R. 15 E. (about 1,800 feet west and 50 feet north of section corner):

A1—0 to 2 inches, gray (10YR 5/1) silt loam, dark grayish brown (10YR 4/2) when moist; weak, thin, platy structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; common roots; porous; many vesicular pores; silt lining in pores; slightly acid (pH 6.2); clear, smooth boundary.

A2—2 to 5 inches, light-gray (10YR 7/1) silt loam, gray (2.5Y 5/1) when moist; moderate, thin, platy structure; slightly hard when dry, firm when moist, sticky and slightly plastic when wet; roots common; slightly porous, the pores filled with silt; neutral (pH 6.6); abrupt, irregular boundary.

B21t—5 to 13 inches, light brownish-gray (2.5Y 6/2) clay, dark grayish brown (2.5Y 4/2) when moist; moderate, medium, columnar structure breaking to strong, fine, blocky structure; hard when dry, firm or very firm when moist, very sticky and very plastic when wet; few roots restricted to vertical surfaces of peds; few pores; coating of bleached silt on top of columns: thick, continuous clay films on vertical surfaces of peds; neutral (pH 6.6); clear, wavy boundary.

B22t—13 to 22 inches, grayish-brown (2.5Y 5/2) clay, dark grayish brown (2.5Y 4/2) when moist; moderate, medium and coarse, prismatic structure breaking to strong, fine and medium, blocky structure; hard when dry, very firm when moist, sticky and plastic when wet; roots very few and confined to areas between vertical surfaces of peds; very few pores; thick, continuous clay films on peds and in pores; neutral (pH 6.9); gradual, smooth boundary.

B3t—22 to 32 inches, grayish-brown (2.5Y 5/2) clay, dark grayish brown (2.5Y 4/2) when moist; moderate, medium, blocky structure; hard when dry, firm or very firm when moist, sticky and plastic when wet; roots very few or none; continuous, moderately thick clay films; higher proportion of pumice than horizon above; mildly alkaline (pH 7.4); gradual, smooth boundary.

C1—32 to 44 inches, grayish-brown (2.5Y 5/2) clay, dark grayish brown (2.5Y 4/2) when moist; moderate, fine and medium, blocky structure; hard when dry, firm or very firm when moist, sticky and plastic when wet; no roots; no pores; mildly alkaline (pH 7.6); gradual, smooth boundary.

C2—44 to 60 inches, dark grayish-brown (2.5Y 4/2) light clay, very dark grayish brown (2.5Y 3/2) when moist; massive; hard when dry, firm or very firm when moist, plastic and sticky when wet; no roots; no pores; mildly alkaline (pH 7.7); gradual transition to either basalt bedrock or lacustrine sediments at a depth of few to many feet.

VEAZIE SERIES

Profile of Veazie loam in a pasture located in the SE¼SE¼SW¼ sec. 13, T. 14 S., R. 18 E. (about 300 feet west and 200 feet north of the south quarter corner):

A1—0 to 9 inches, dark-gray (10YR 4/1) loam, very dark brown (10YR 2/2) when moist; weak or moderate, thin and very thin, platy structure crushing to weak, fine, granular structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; abundant roots; pores mainly interstitial; pH 6.6 to 7.0; clear, smooth boundary.

AC—9 to 16 inches, grayish-brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) when moist; weak, very fine, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; abundant roots; pores mainly interstitial; pH 6.6 to 7.0; clear, smooth boundary.

C1—16 to 24 inches, grayish-brown (10YR 5/2), stratified loam, silt loam, and very fine sandy loam, very dark grayish brown (10YR 3/2) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; plentiful roots; pH 6.6 to 7.0; abrupt, smooth boundary.

IIC2—24 inches +, grayish-brown (10YR 5/2) very gravelly sand, very dark grayish brown (10YR 3/2) when moist; single grain (structureless); loose when dry and when moist, nonsticky and nonplastic when wet; few roots; dominantly stratified gravel and sand, with thin layers of loam or very fine sandy loam in places; pH 6.6 to 7.0.

Laboratory Data

Table 11 gives laboratory data for nine selected soils, each a soil of an important series. The series are Ayres, Crooked, Elmore, Lamonta, Ochoco, Prineville, Searles, Stearns, and Swartz. The profiles of these soils are described in the subsection "Descriptions of Soil Profiles."

Standard methods were used to obtain the data in table 11. Particle-size distribution was determined by use of the pipette method (*3*). To determine pH, laboratory distilled water was added to 20 grams of soil to make a consistency of the saturation percentage, and allowed to stand for 1 hour before reading the pH in a Beckman Model H-2 meter. The same sample was subsequently diluted with distilled water to a 1:10 soil-water ratio, and the pH was determined after 1 hour. The electrodes were placed deep in the suspension immediately after the final stirring.

Organic carbon was determined by the $K_2Cr_2O_7$-H_2SO_4 heat of dilution method described in "Methods of Soil Analysis for Soil-Fertility Investigations," U.S. Department of Agriculture Circular No. 757 (*5*). Soil was removed by filtration prior to titration with $FeSO_4$ and ortho-phenanthroline as indicator. Organic carbon was calculated on the basis of 77 percent oxidation of organic matter.

Total nitrogen was determined by the Kjeldahl method. Electrical conductivity of the saturation extract was analyzed by a method described in "Diagnosis and Improvement of Saline and Alkali Soils," U.S. Department of Agriculture Handbook No. 60 (*12*). The calcium carbonate equivalent was determined by measuring the volume of carbon dioxide evolved from soil samples treated with four normal hydrochloric acid (HCl) in a 50-milliliter test tube. Carbon dioxide was removed by vacuum at short intervals, and a trap containing cotton was used to prevent the loss of water vapor.

Measurement of moisture retention at 1/10, 1/3, and 15 atmospheres were made by methods 29, 30, and 31, respectively, described in USDA Handbook No. 60. Method 19 of USDA Handbook No. 60 was followed to determine cation exchange capacity, except that 10 grams of soil were used. Following the removal of NH_4Ac and organic matter by dehydration with HNO_3 and HCl, and after silica was dehydrated with six normal HCl, the residue was dissolved in 0.4 normal HCl, and sodium was determined by a Beckman Model DU flame spectrophotometer.

Methods described in USDA Circular No. 575 (*5*) were used to extract and to prepare alkali- and alkaline-earth cations for analyses. Fifty grams of soil were extracted with one normal neutral NH_4Ac. Calcium was precipitated as the oxalate and titrated with permanganate; Mg as ammonium magnesium phosphate, ignited and weighed as MgP_2O_7. Separate aliquots of the NH_4Ac extracts for sodium and potassium were treated the same as NH_4Ac for determinations of cation exchange capacity. Sodium and potassium were analyzed in 0.4 normal HCl by a Beckman flame spectrophotometer. Determinations of extractable hydrogen were made by the triethanolamine method described in USDA Circular No. 757.

Sodium and potassium in the saturation extract were analyzed by use of a Beckman flame spectrophotometer. Calcium and magnesium were determined according to Method 7 in USDA Handbook No. 60. Extractable Na and K were obtained by subtracting soluble Na and K in the saturation extract from the NH_4Ac-extractable values. The values for extractable Ca and Mg consist of the exchangeable values added to the Ca and Mg in soluble salts, gypsum, and carbonates, if present.

In noncalcareous samples the cation exchange capacity is the sum of Ca, Mg, H, Na, and K. The base saturation percentage is obtained if the extractable hydrogen is subtracted from this sum, and if the result is divided by the sum of the cations, including H, and multiplied by 100.

In calcareous samples the extractable Na divided by the cation exchange capacity, as determined by NaAc procedure, multiplied by 100 represents the exchangeable Na present.

In soils derived from pumice and volcanic glass, and possibly in soils from some weathered basalts, the density and shape of particles differ considerably from those in soils derived from such minerals as quartz, fledspars, "heavy" minerals, and clay minerals of the 2:1 lattice type. When determining particle-size distribution by the pipette method, consideration should be given to the effect of density and shape of particles on settling velocity.

In addition, particles shape influences the moisture retained at various levels of pressure, as do fine pores that may be present. The moisture held at a tension of 15 atmospheres is influenced by the amount and nature of the surface-force field of the soil particles and not by the size of the "capillary" pores. However, the surface-force field of a 2:1 lattice-type clay mineral differs from that of a pumice particle having pores of various sizes. In coarse-textured soils a high percentage of moisture held at a tension of 15 atmospheres may result from a high content of particles with fine pores.

In table 11 the percentage of particles larger than 2 millimeters includes fragments as large as 1 inch across. Coarse fragments larger than about 1 inch across were excluded from samples brought to the laboratory, but estimates of coarse fragments are given in the profile descriptions.

Facts About Crook County

This section provides general information about the climate, history, population, transportation and markets, water supply, land use, and agriculture of Crook County.

Climate [3]

Crook County is just outside the northwest corner of the Great Basin. The climate is semiarid, the nights are fairly cool throughout the year, and most of the annual precipitation occurs in winter.

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[3] GILBERT L. STERNES, State climatologist, prepared this subsection.

TABLE 11.—*Laboratory data on some*

[Analyses by Soil Survey Laboratory, SCS, Riverside,

Soil type and profile number	Depth	Horizon	Particle-size distribution										pH	
			Very coarse sand (2.0–1.0 mm.)	Coarse sand (1.0–0.5 mm.)	Medium sand (0.5–0.25 mm.)	Fine sand (0.25–0.10 mm.)	Very fine sand (0.10–0.05 mm.)	Silt (0.05–0.002 mm.)	Clay (less than 0.002 mm.)	Other size classes			Saturated paste	1:10 suspension
										0.2 to 0.02 mm.	0.02 to 0.002 mm.	Larger than 2 mm.		
Ayres gravelly sandy loam:	*Inches*		*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*		
S55–Oreg.–7–3.	0–5	A1	1.9	10.7	17.4	24.9	10.0	23.0	12.1	31.6	13.2	17	6.8	6.9
	5–8	A3	1.5	10.4	15.5	23.3	9.8	24.2	15.3	30.4	15.2	11	6.8	7.1
	8–14	B2t	1.4	7.1	9.6	16.7	9.3,	26.6	29.3	28.1	16.8	10	7.1	7.2
	14–29	C1sim	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	------	------
	29–50+	C2	------	------	------	------	------	------	------	------	------	------	------	------
Crooked sandy loam: S55–Oreg.–7–11.[2]	0–6	Ap	1.3	12.3	16.3	26.6	12.4	24.7	6.4	38.2	12.8	0	9.1	9.8
	6–13	AC	1.5	12.1	14.8	27.3	15.5	22.1	6.7	44.9	8.1	1	9.4	9.9
	13–20	C1m	1.3	4.3	5.1	20.3	26.5	34.5	8.0	63.9	11.7	2	8.6	9.6
	20–33	C2m	.3	3.6	6.3	33.3	28.0	23.7	4.8	68.4	8.0	0	8.1	8.9
	33–48	C3	.3	2.4	4.4	25.8	31.1	32.2	3.8	71.4	11.5	0	8.8	9.1
Elmore very stony loam: S55–Oreg.–7–5.	0–5	A1	1.2	3.5	3.3	13.0	14.1	48.3	16.6	45.0	26.4	14	6.3	6.6
	5–9	A3	1.8	3.2	3.3	11.4	13.9	45.5	20.9	42.3	25.0	11	6.3	6.5
	9–14	B1t	1.6	2.5	2.6	11.3	14.2	43.3	24.5	42.1	23.2	19	6.4	6.6
	14–23	B21t	1.2	2.0	2.4	11.2	17.6	37.6	28.0	41.8	21.8	41	7.0	7.0
	23–35	B22t	1.5	1.6	1.8	10.1	15.1	41.0	28.9	42.5	21.1	39	6.5	6.5
	35–50	B23t	1.4	3.3	3.8	12.3	15.0	32.1	32.1	36.4	19.3	44	7.0	7.4
	50+	(4)	------	------	------	------	------	------	------	------	------	------	------	------
Lamonta gravelly loam: S55–Oreg.–7–13.	0–7	Ap	3.3	5.3	6.9	18.3	13.4	36.9	15.9	42.4	18.7	14	6.7	6.9
	7–8½	B1	3.2	4.8	5.8	15.5	10.4	31.3	29.0	12.8	38.2	26	6.5	6.7
	8½–20	B21t	1.3	2.6	2.7	7.1	5.0	17.6	63.7	18.4	8.4	13	7.1	8.1
	20–23	B22t	2.3	3.4	3.1	6.7	4.9	16.5	63.1	16.1	9.4	18	7.6	8.4
	23–36	Csim	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	------	------
Ochoco sandy loam: S55–Oreg.–7–15.	0–8	Ap	1.2	10.9	21.7	30.4	8.0	18.7	9.1	31.3	9.1	4	7.3	7.5
	8–16	A3	1.2	10.6	21.7	29.3	8.0	18.7	10.5	29.8	9.8	7	7.3	7.5
	16–21	B1	1.3	8.6	16.2	23.1	8.5	24.2	18.1	31.7	12.0	3	7.3	7.6
	21–28	B2t	1.1	7.1	14.6	22.2	9.2	24.4	21.4	32.4	12.2	4	7.3	7.6
	28–36	B3	2.1	13.3	23.3	25.8	4.8	8.9	21.8	19.6	4.8	20	7.4	7.8
	36–46	C1mca	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	------	------
	46–60	C2ca	1.5	17.7	38.6	38.5	0	.6	3.1	12.5	1.5	7	8.1	9.0
Prineville sandy loam: S55–Oreg.–7–18.	0–9	Ap	2.1	12.9	17.2	25.6	12.4	22.9	6.9	37.4	11.1	3	7.1	7.1
	9–16	A3	1.6	10.2	14.5	26.3	16.0	23.1	8.3	45.0	9.0	4	7.7	7.8
	16–20	B2	1.6	8.3	11.5	23.1	18.6	26.4	10.5	46.3	12.4	5	8.2	8.7
	20–32	C1m	1.5	5.9	6.9	18.9	24.5	29.1	3.2	61.8	14.8	4	8.6	9.2
	32–47	C2m	1.2	5.1	6.8	21.5	25.3	40.1	0	62.8	17.5	5	8.6	9.2
	47–60	C3	1.9	8.3	12.7	30.3	23.1	23.7	0	57.5	8.5	22	8.5	9.0
Searles stony loam: S55–Oreg.–7–7.	0–3	A1	3.6	6.0	4.9	13.6	15.3	38.7	17.9	41.4	22.0	47	6.8	6.9
	3–8	A3	3.1	5.3	4.5	12.1	14.4	38.4	22.2	38.1	23.1	49	6.8	7.0
	8–18	B21t	2.7	4.1	3.6	11.1	14.2	37.8	26.5	37.1	22.7	53	7.0	7.1
	18–25	B22t	3.7	3.9	3.4	11.1	14.2	37.7	25.8	36.9	23.1	54	7.3	7.2
	25–40	C	3.1	3.3	4.4	17.5	21.3	32.8	17.6	47.9	19.0	60	7.2	7.4
	40+	(4)	------	------	------	------	------	------	------	------	------	------	------	------

See footnotes at end of table.

selected soils of the Prineville Area

California. Dashes indicate data not available or not determined]

Organic matter			Electrical conductivity (EC×10³) mmhos. per cm. at 25° C.	CaCO₃ equivalent	Moisture held at tensions of—			Moisture at saturation	Cation exchange capacity (Na)	Extractable cations (meq. per 100 gm.)					Base saturation	Saturation extract soluble (meq. per liter)		
Organic carbon	Nitrogen	C/N ratio			1/10 atmosphere	1/3 atmosphere	15 atmospheres			Ca	Mg	H	Na	K		Na	K	Ca +Mg
Percent	*Percent*			*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Meq. per 100 gm.*						*Percent*			
0.73	0.064	11.4	0.5	------	28.0	21.3	9.8	------	19.8	9.6	4.7	2.6	0.4	1.5	86	------	------	------
.55	.061	9.0	.4	------	30.5	24.2	11.6	------	24.2	11.5	5.6	3.3	.2	1.2	85	------	------	------
.65	.072	9.0	.4	------	38.3	29.3	17.2	------	40.3	21.8	11.5	2.8	.8	1.4	93	------	------	------
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.57	.056	10.2	2.3	2	34.2	20.1	16.5	39.8	21.7	17.6	2.3	------	9.5	5.2	[3] 44	25.0	1.0	2.0
.33	.037	8.9	1.9	4	31.9	20.3	18.0	42.8	21.6	16.2	3.5	------	11.2	4.6	[3] 52	21.8	.7	6.2
.22	.023	9.6	1.9	6	45.4	30.3	23.1	51.3	40.4	17.9	11.5	------	17.9	6.9	[3] 44	20.0	.6	2.2
.14	.016	8.8	1.7	3	35.7	20.3	13.5	40.9	27.6	24.9	8.9	------	3.5	1.8	[3] 13	13.4	.3	4.4
.13	------	------	1.5	5	39.4	24.9	14.0	43.3	35.0	24.1	10.9	------	11.0	5.3	[3] 31	15.2	.5	1.2
2.40	.182	13.2	.5	------	50.5	31.3	12.6	------	26.6	11.5	5.8	5.4	.2	1.8	78	------	------	------
1.69	.142	11.9	.5	------	49.9	27.4	13.4	------	27.9	12.5	6.8	5.3	.2	1.5	80	------	------	------
1.47	.127	11.6	.4	------	46.8	27.3	14.5	------	30.5	13.7	8.0	5.7	.2	1.3	80	------	------	------
1.04	.096	10.8	.5	------	41.1	28.4	32.1	------	39.3	16.9	12.2	4.7	.7	1.9	87	------	------	------
1.41	.135	10.4	.5	------	42.4	29.2	17.4	------	36.5	16.8	10.6	5.7	.3	1.6	84	------	------	------
.45	.047	9.6	.5	------	36.1	26.6	16.1	------	35.5	14.8	30.2	3.2	.7	1.4	94	------	------	------
------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
1.13	.092	12.3	.5	------	38.4	24.0	10.4	------	22.8	11.2	5.2	2.7	.5	2.1	88	------	------	------
.87	.058	15.0	.5	------	42.4	29.2	15.8	------	33.9	15.5	8.5	2.6	1.0	1.8	91	------	------	------
.59	.057	10.4	.3	------	86.9	67.8	38.2	------	69.9	35.8	23.9	4.3	2.6	2.6	94	------	------	------
.59	------	------	.5	------	88.6	71.8	40.2	------	76.5	42.2	27.5	3.1	3.2	2.5	96	------	------	------
------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
.64	.062	10.3	.6	------	24.6	16.5	7.1	------	16.3	9.8	3.8	1.4	.6	1.0	92	------	------	------
.34	.039	8.7	.5	------	25.4	16.0	8.1	------	17.3	9.9	4.7	.8	.5	1.0	95	------	------	------
.23	.031	7.4	.4	------	31.1	20.9	10.3	------	23.5	12.7	7.6	.8	.6	1.3	97	------	------	------
.18	.026	6.9	.5	------	34.9	23.7	12.0	------	27.5	15.0	9.9	.9	.5	1.6	97	------	------	------
.17	.021	8.1	.6	------	30.2	22.1	12.7	------	28.1	15.8	11.0	.7	.5	1.5	98	------	------	------
------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
.06	------	------	.5	1	5.6	4.5	3.3	------	9.6	15.7	3.6	------	.4	.6	100	------	------	------
.67	.067	10.0	.7	------	29.5	17.9	8.4	------	17.9	9.1	4.4	1.7	.7	1.5	90	------	------	------
.50	.054	9.3	.5	------	31.8	17.5	8.6	------	19.2	9.5	5.9	.9	.9	1.0	95	------	------	------
.41	.050	8.2	.9	------	32.7	20.6	9.6	------	24.3	8.5	8.6	.5	[6] 2.9	1.9	98	------	------	------
.20	.028	7.1	1.2	<1	33.5	20.5	9.9	------	26.2	15.3	10.7	------	[6] 4.8	2.4	100	------	------	------
.18	.024	7.5	1.1	2	31.4	20.1	8.9	------	24.1	18.4	9.7	------	[6] 3.9	2.1	100	------	------	------
.16	.019	8.4	.9	3	26.5	16.2	8.4	------	20.7	20.8	11.5	------	[6] 2.9	1.9	100	------	------	------
1.00	.093	10.8	.4	------	38.3	25.9	11.3	------	25.2	12.6	6.2	3.4	.5	1.7	86	------	------	------
.95	.087	10.9	.4	------	38.6	24.8	13.2	------	29.9	15.1	7.6	3.2	.4	2.0	89	------	------	------
.78	.089	8.8	.5	------	39.2	26.6	15.4	------	32.7	17.4	10.0	3.0	.4	2.0	91	------	------	------
.77	.086	9.0	.4	------	41.9	27.9	16.7	------	36.4	18.5	12.2	3.1	.6	1.6	91	------	------	------
.77	.090	8.6	.4	------	42.6	27.6	18.9	------	47.8	22.4	17.6	2.6	.7	1.9	94	------	------	------
------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------

TABLE 11.—*Laboratory data on some selected*

Soil type and profile number	Depth	Horizon	Particle-size distribution										pH	
			Very coarse sand (2.0–1.0 mm.)	Coarse sand (1.0–0.5 mm.)	Medium sand (0.5–0.25 mm.)	Fine sand (0.25–0.10 mm.)	Very fine sand (0.1–0.05 mm.)	Silt (0.05–0.002 mm.)	Clay (less than 0.002 mm.)	Other size classes			Saturated paste	1:10 suspension
										0.2 to 0.02 mm.	0.02 to 0.002 mm.	Larger than 2 mm.		
	Inches		*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*		
Stearns silt loam: S55–Oreg.–7–10.	0–3	A21	.1	1.1	.7	4.0	10.5	72.5	11.1	46.0	40.1	0	6.8	7.8
	3–5	A22	.1	.4	.5	3.5	10.9	70.8	13.8	46.2	38.2	0	7.3	8.7
	5–13	B2t	.0	.2	.5	3.9	10.4	55.6	29.4	38.9	30.2	0	9.2	10.0
	13–22	C1m	.1	1.2	2.3	13.6	20.4	51.8	10.0	56.1	26.8	0	9.6	10.1
	22–36	C2m	.3	2.2	2.8	11.0	17.7	59.7	6.3	54.9	30.2	0	9.2	9.8
	36–48	C3	.2	1.5	2.6	8.3	11.6	65.1	10.7	48.8	33.0	0	8.9	9.8
	48–60	C4	.2	6.8	12.9	34.2	12.6	25.8	7.5	43.4	12.5	0	8.7	9.6
Swartz silt loam: S55–Oreg.–7–1.	0–2	A1	.4	2.0	2.3	9.2	10.5	62.7	12.9	47.6	31.6	0	6.2	6.8
	2–5	A2	.1	1.6	2.1	7.6	9.1	61.5	18.0	39.5	36.2	0	6.6	7.4
	5–13	B21t	.1	.6	1.0	2.4	1.9	31.3	62.7	17.8	16.8	0	6.6	6.9
	13–22	B22t	.1	.9	1.2	2.7	1.9	31.4	61.8	12.7	22.1	1	6.9	7.6
	22–32	B3t	.1	.8	1.1	2.4	1.9	35.1	58.6	13.9	24.4	0	7.4	7.5
	32–44	C1	.1	.6	.8	1.9	2.1	36.9	57.6	15.0	25.2	0	7.6	8.0
	44–60	C2	.0	.5	1.0	2.6	2.5	39.7	53.7	21.2	22.5	0	7.7	7.7

[1] Indurated hardpan.

[2] Color of saturation extracts from this profile varied from yellow to dark amber to black.

[3] Exchangeable sodium percentage.

Normally the air movement over the county is from the west and, because the Pacific Ocean is only 150 miles away, the air masses are mostly of marine origin. In their passage over the Coast Range and the Cascade Mountains, however, these masses of air are greatly modified, especially in winter when most of the storms occur and precipitation is heaviest. In winter the ground is much colder than the ocean, and air from off the water is cooled rapidly as it moves over the Coast Range and then, some 50 to 75 miles further, begins its ascent of the Cascades. The air is cooled by contact with the colder ground over which it passes and by its rise up the mountains. The temperature is lowered at the rate of 3° to 5° F. for each 1,000 feet of increase in elevation. Cooling causes the air to give up a large part of the moisture available for precipitation.

As the air moves down the east slopes of the Cascades and passes over the central Oregon plateau, its capacity to hold moisture increases but its content of moisture greatly decreases. In a distance of 30 to 35 miles, from the crest of the Cascades to the western edge of the plateau, the average annual precipitation decreases from more than 65 inches to less than 9 inches. As the air continues to move eastward, it begins to ascend the Ochoco Mountains. The rise in elevation again causes an increase in precipitation, which is substantial on the upper slopes of the mountains.

The Cascade Mountains also have a strong influence on the extremes in temperature that occur on the central Oregon plateau in winter. This influence is exerted in two ways—

(1) Near the surface of the upper eastern slopes, cold air is formed on cold winter nights. Because it is heavy, the cold air moves by gravitation down the mountain slopes to the plateau. Here it accumulates and, by pushing under, forces the preexisting warmer air to ride on top of it. This air movement occurs during periods of calm air or of very light winds. If it persists for several days, a deep pool of stagnant cold air builds up over the plateau. Cold is intensified by a cloud layer that tends to form near the top of the pool and prevents solar heating during the day.

(2) Over the snow and icefields of north-central Canada, masses of cold Arctic air form in winter and generally move southward along the eastern edge of the Rocky Mountains. In most winters, however, segments of Arctic air occasionally break over the Continental Divide. The Cascade Mountains usually are an effective barrier against further movement westward, and the segments are forced to continue southward between the Rocky Mountains and the Cascades. Nearly always the Arctic air is very cold and dry, and usually it causes the lowest temperatures in Crook County and other parts of the central plateau of Oregon. In addition, the heaviest snowfalls on central Oregon occur when a fairly severe storm, consisting of modified marine air, moves in from the west and collides with a mass of cold Arctic air moving down from the north.

Agriculture in Crook County is in three areas that are fairly well defined—the Deschutes plateau, the Crooked River valley and adjacent terraces, and the upper narrow valleys. Although the first two areas have *soils of the Prineville Area*—Continued

Organic matter			Electrical conductivity (EC$\times 10^3$) mmhos. per cm. at 25° C.	$CaCO_3$ equivalent	Moisture held at tensions of—			Moisture at saturation	Cation exchange capacity (Na)	Extractable cations (meq. per 100 gm.)					Base saturation	Saturation extract soluble (meq. per liter)		
Organic carbon	Nitrogen	C/N ratio			1/10 atmosphere	1/3 atmosphere	15 atmospheres			Ca	Mg	H	Na	K		Na	K	Ca +Mg
Percent	*Percent*			*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Meq. per 100 gm.*						*Percent*			
3.25	.244	13.3	2.3	------	58.6	36.6	20.5	55.6	31.0	10.5	4.6	-----	7.7	4.9	[3] 25	22.0	1.0	2.2
2.40	.206	11.7	3.4	------	54.8	38.8	22.0	54.9	34.6	10.5	4.6	-----	14.1	4.5	[3] 41	51.5	.5	2.2
1.13	.094	12.0	9.3	1	68.1	56.1	38.6	66.6	48.7	9.7	3.6	-----	35.4	4.1	[3] 73	82.0	.7	4.1
.42	.035	12.0	7.7	1	56.0	41.8	26.4	52.5	42.6	14.5	2.7	-----	30.0	2.1	[3] 70	86.0	.4	3.1
.41	.037	11.1	4.0	8	52.9	37.7	25.7	52.5	45.3	16.6	4.2	-----	27.1	1.2	[3] 60	59.5	.3	3.3
.33	.033	10.0	2.2	2	58.0	41.6	26.1	55.2	45.4	18.9	6.6	-----	25.8	.5	[3] 57	24.6	.3	1.6
.16	------	------	1.1	1	35.9	25.1	16.9	43.6	30.6	19.9	7.9	-----	10.3	.2	[3] 34	12.1	.2	(7)
1.39	.115	12.1	.4	------	37.1	29.4	7.9	------	18.8	7.0	3.8	5.5	.4	1.7	70	------	-----	------
.66	.058	11.4	.3	------	33.2	27.7	8.0	------	16.9	6.8	4.2	2.7	.8	1.2	83	------	-----	------
.48	.046	10.4	.5	------	75.6	57.0	39.2	------	58.7	25.1	16.6	4.2	2.8	2.6	92	------	-----	------
.28	.035	8.0	.4	------	72.2	53.7	32.2	------	54.0	24.6	16.8	3.2	3.0	2.5	94	------	-----	------
.20	.025	8.0	.4	------	64.1	47.1	29.0	------	47.1	22.5	17.0	2.0	2.6	2.6	96	------	-----	------
.17	.020	8.5	.3	------	64.0	46.6	27.7	------	50.0	19.8	14.2	1.4	4.1	4.2	97	------	-----	------
.17	.021	88.1	.3	------	62.9	46.8	27.6	------	49.5	26.3	11.6	1.5	3.3	2.8	97	------	-----	------

[4] Rhyolite rock.

[5] Weakly to strongly cemented lime-silica hardpan.

[6] 12 to 18 percent is exchangeable sodium.

[7] Trace.

similar climate, temperature and precipitation data are given separately for each area in table 12. The general characteristics of climate in the county are discussed in the following paragraphs.

Precipitation.—The average annual precipitation in Crook County ranges from slightly more than 8 inches on the Deschutes plateau to more than 19 inches in the highest parts of the upper valleys used for agriculture. More than half the precipitation falls during the 5 months of October through February, but the amount is proportionately much less than that falling on most of the State during the same period. Showers and thunderstorms produce a significant amount of rainfall from March through June, but only about 10 percent of the yearly precipitation occurs in July, August, and September. On the Deschutes plateau and in the Crooked River valley, on the average, 25 to 35 days a year have as much as 0.10 inch of rainfall per day. In contrast are the upper valleys, where, on the average, 55 to 60 days a year have as much as 0.10 inch of rainfall per day.

At lower elevations much of the precipitation in winter falls as rain. Snow accumulates to a depth of 1 inch or more on only 6 to 8 days a year, and it generally melts in a few hours or, at most, 3 or 4 days. In the upper valleys, however, snow is more abundant, and a depth of as much as 3½ feet has been recorded. In most winters snow at least 15 inches deep can be expected in these valleys, and a depth of 30 inches is not uncommon.

Following short periods of heavy rainfall, rapid runoff causes erosion and creates problems in the design of drainage culverts. Table 13 gives the amount of rainfall, lasting for a specified length of time from 20 minutes to 24 hours, that can be expected once in the return periods indicated. For example, at least once in 2 years, 0.3 inch of rain can be expected to fall during a 20-minute period, but only once in 100 years is it likely that as much as 0.7 inch will fall during a period of 20 minutes. The table was prepared from nomograms in U.S. Weather Bureau Tech. Paper No. 28 (*16*) and is useful in the agricultural areas of the county.

Temperature.—Extremes in temperature, recorded at Prineville in the Crooked River valley, range from a low of —35° F. to a high of 119°, which equals the all-time high temperature recorded in the State. A freezing temperature of 32° or lower can be expected in all parts of the county in any month of the year. In table 14 are listed, for the agricultural areas of the county, the probabilities that there will be freezing temperatures of stated intensities in spring after the dates listed and in fall before the dates listed.

Wind.—The growing use of airplanes in applying fertilizer, herbicides, and insecticides has led to heightened interest in wind velocities. Wind speed is of interest also because of its influence on the construction of farm buildings and the lodging of uncut hay and grain. Strong easterly winds moving into the county normally bring dry, very cold air in winter and warm, very dry air in summer. These winds in summer deplete soil moisture, rapidly dehydrate vegetation, and often cause a critical danger of fire on forest and grassland.

TABLE 12.—*Temperature and precipitation in three agricultural areas of Crook County*

Month	Temperature				Precipitation												
	Average daily		2 years in 10 will have at least 4 days with—		Monthly average	1 year in 10 will have—		2 years in 10 will have—		3 years in 10 will have—		4 years in 10 will have—		Average snowfall	Maximum depth of snow on ground	Average number of days with snow cover	Average depth of snow on days with snow cover
	Maximum	Minimum	Maximum equal to or higher than—	Minimum equal to or lower than—		Less than—	More than—	Less than—	More than—	Less than—	More than—	Less than—	More than—				
DESCHUTES PLATEAU																	
	°F.	*°F.*	*°F.*	*°F.*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*		*Inches*
January	42	21	56	2	1.1	0.4	1.9	0.5	1.5	0.6	1.3	1.0	1.2	6.6	15	8	4
February	47	25	60	8	.8	.1	1.4	.4	1.3	.4	1.1	.5	.8	3.4	9	4	4
March	54	27	69	16	.6	(1)	1.3	.2	1.0	.2	.7	.3	.6	1.3	5	1	2
April	62	31	78	21	.5	(1)	1.2	.1	1.0	.2	.7	.3	.5	.7	1	(2)	1
May	69	37	85	26	1.0	.2	2.2	.3	1.7	.4	1.0	.6	.7	(1)	1	(2)	1
June	75	42	90	33	1.0	(1)	2.4	.2	1.9	.4	1.2	.6	1.0	0	0	0	0
July	85	47	96	37	.3	0	.8	(1)	.6	.1	.4	.1	.3	0	0	0	0
August	83	45	94	36	.2	0	.8	0	.6	(1)	.3	(1)	.2	0	0	0	0
September	76	40	90	29	.5	(1)	1.1	(1)	.8	.1	.6	.2	.5	0	0	0	0
October	65	34	81	23	.7	.1	1.5	.2	1.2	.3	.9	.4	.7	.2	4	(2)	2
November	52	28	66	12	.9	.1	1.8	.2	1.8	.4	1.3	.7	1.0	1.0	5	1	2
December	45	25	58	9	1.1	.2	2.1	.4	1.9	.4	1.3	.8	1.2	3.2	6	2	2
Annual	63	33	[3] 98	[4] −6	8.7	5.0	12.0	6.2	10.4	7.1	9.6	8.2	9.0	16.4	15	16	3
CROOKED RIVER VALLEY AND TERRACES																	
January	41	19	55	3	1.1	.4	1.9	.5	1.5	.7	1.3	.9	1.2	6.3	16	6	4
February	46	24	58	9	.8	.2	2.1	.4	1.2	.5	.8	.6	.7	2.9	8	3	3
March	53	26	68	13	.7	.1	1.6	.2	.9	.3	.8	.4	.8	1.4	6	(2)	3
April	62	30	78	19	.7	.1	1.3	.2	1.1	.3	.9	.7	.8	.4	(5)	(2)	1
May	68	35	83	25	1.2	.2	2.2	.4	2.1	.7	1.6	.8	1.4	(1)	(5)	(2)	(5)
June	74	40	90	31	1.2	.1	2.9	.1	2.0	.5	1.6	.8	1.4	0	0	0	0
July	85	42	95	34	.3	(1)	.8	(1)	.6	(1)	.4	.2	.3	0	0	0	0
August	83	39	94	31	.3	(1)	.8	(1)	.6	.1	.4	.1	.2	0	0	0	0
September	77	34	91	24	.5	(1)	1.1	.1	.8	.3	.6	.3	.5	.1	2	(2)	2
October	65	30	82	18	.8	.1	1.8	.3	1.3	.5	1.0	.6	.9	.3	3	(2)	2
November	52	25	65	10	1.1	.2	2.3	.4	1.8	.7	1.5	.8	1.4	.9	3	(2)	2
December	44	23	56	8	1.1	.3	2.0	.4	1.8	.5	1.5	.8	1.4	2.6	5	2	2
Annual	63	31	[3] 98	[4] −7	9.8	6.7	13.6	7.4	12.2	8.7	11.2	9.4	10.8	14.9	16	11	3
UPPER NARROW VALLEYS																	
January	35	15	45	−6	2.2	.7	3.8	1.2	2.9	1.6	2.8	1.7	2.4	19.8	43	28	11
February	40	20	49	4	1.9	.8	3.2	1.1	2.9	1.2	2.7	1.5	1.9	14.1	36	26	14
March	47	22	62	10	1.7	.8	2.6	1.0	2.4	1.3	2.2	1.5	2.0	11.0	34	20	11
April	54	27	73	19	1.3	.2	2.3	.5	1.9	.9	1.6	1.1	1.3	1.8	15	1	5
May	64	33	80	24	1.9	.5	3.8	.8	3.4	1.1	2.8	1.4	2.2	.4	2	(2)	2
June	71	37	86	29	1.7	.1	3.7	.3	3.3	.5	2.2	1.3	2.1	.1	0	0	0
July	82	41	93	33	.8	(1)	1.8	(1)	1.2	.1	.7	.4	.5	(1)	0	0	0
August	81	39	92	31	.6	0	1.6	(1)	1.1	.1	1.0	.2	.7	0	0	0	0
September	75	35	89	26	.8	.1	1.6	.2	1.3	.4	.9	.6	.9	.2	0	0	0
October	60	30	78	22	1.8	.2	3.8	.8	3.0	.9	2.4	.1	1.7	1.3	5	1	3
November	44	24	57	11	2.3	.6	4.8	.9	3.5	1.1	2.8	1.9	2.6	7.1	14	8	4
December	37	20	47	5	2.6	1.1	5.1	1.4	4.5	1.6	2.8	1.9	2.3	13.4	26	18	8
Annual	58	29	[3] 96	[4] −11	19.3	13.7	25.4	14.8	23.9	16.5	20.9	18.7	20.0	69.2	43	102	11

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[1] Trace.
[2] Less than half a day.
[3] Average annual highest temperature.
[4] Average annual lowest temperature.
[5] Less than 0.5 inch.

TABLE 13.—*Amount of rainfall of stated duration to be expected once in the specified number of years*

Duration	Return period of—						
	2 years	5 years	10 years	25 years	50 years	75 years	100 years
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
20 minutes	0.3	0.4	0.5	0.5	0.6	0.7	0.7
30 minutes	.4	.4	.5	.7	.8	.8	.9
1 hour	.4	.6	.7	.8	.9	1.0	1.1
2 hours	.6	.8	.8	1.0	1.2	1.2	1.4
3 hours	.8	.9	1.1	1.3	1.5	1.6	1.7
6 hours	1.0	1.3	1.4	1.7	1.8	1.9	2.0
12 hours	1.3	1.6	1.8	2.0	2.3	2.4	2.5
24 hours	1.5	1.8	2.1	2.4	2.7	2.9	3.0

Table 15 and figure 12 give data on wind velocities based on hourly observations at the Redmond Airport, Deschutes County, during a period of 4½ years. Prevailing wind at the airport is from the west to northwest most of the year, but it is from the south to southeast late in fall and early in winter.

Humidity.—The relative humidity rises during the night because the air is cooled while its content of water vapor remains constant. At 4:00 a.m., the relative humidity is highest and, on the average, is 75 to 80 percent throughout the year. At 4:00 p.m., the humidity generally is lowest for the day and, on the average, ranges from a high of 65 to 70 percent in December to a low of 20 to 25 percent in July. If winds are fairly strong from the east or southeast, the relative humidity may fall as low as 8 to 10 percent during the day. In periods of highest temperature, discomfort is minimized by low relative humidity. Table 16 shows the average relative humidity, by months, recorded four times a day at the Redmond Airport, Deschutes County. Records are incomplete for agricultural areas in Crook County, but data in table 16 are considered representative.

Thunderstorms.—Most of the precipitation in summer accompanies infrequent thunderstorms that bring light rainfall and, at times, hail. These storms are more frequent at the higher elevations. On the Deschutes plateau and in the Crooked River valley, 6 to 12 storms occur annually, but in the upper valleys of the Ochoco Mountains, 15 to 25 storms occur each year. Particularly hazardous are the dry thunderstorms that bring lightning and thunder but no rain. At times, lightning ignites grass, brush, and timber, and fires spread unchecked because moisture is lacking.

Hail.—A few hailstorms occur each year, but in most years they cause little or no damage. In only a few years have storms brought hail that caused fairly heavy losses in small local areas. In Crook County, there is no record of hailstorms that were widespread and severe enough to affect the economy.

Tornadoes.—True tornadoes are almost unknown in Oregon, and none has been recorded in Crook County. On a warm day in summer, several dust devils may develop that are a few feet to 10 or 15 yards in diameter and extend upward as much as 2,000 to 3,000 feet. In contrast to a tornado, which extends from a cloud downward, a dust devil begins at the ground and gradually rises. Dust devils occasionally overturn a small, lightly constructed farm building and may damage a roof or an awning, but they do not affect a substantial structure.

TABLE 14.—*Probabilities of last freezing temperatures in spring and first in fall*

Probability	Dates for given probability and temperature			
	16° or lower	20° or lower	24° or lower	28° or lower
DESCHUTES PLATEAU				
Spring:				
1 year in 10, later than.	Apr. 5	Apr. 25	May 21	June 5
2 years in 10, later than.	Mar. 29	Apr. 18	May 14	May 29
5 years in 10, later than.	Mar. 16	Apr. 5	May 1	May 16
Fall:				
1 year in 10, earlier than.	Oct. 28	Oct. 11	Sept. 28	Sept. 7
2 years in 10, earlier than.	Nov. 4	Oct. 18	Oct. 5	Sept. 14
5 years in 10, earlier than.	Nov. 17	Oct. 31	Oct. 18	Sept. 27
CROOKED RIVER VALLEY				
Spring:				
1 year in 10, later than.	Apr. 27	May 3	May 26	June 16
2 years in 10, later than.	Apr. 17	Apr. 27	May 20	June 10
5 years in 10, later than.	Mar. 29	Apr. 16	May 9	May 30
Fall:				
1 year in 10, earlier than.	Oct. 9	Sept. 20	Sept. 3	Aug. 16
2 years in 10, earlier than.	Oct. 16	Sept. 27	Sept. 11	Aug. 22
5 years in 10, earlier than.	Oct. 29	Oct. 10	Sept. 22	Sept. 4
UPPER NARROW VALLEYS				
Spring:				
1 year in 10, later than.	Apr. 18	May 10	June 4	June 28
2 years in 10, later than.	Apr. 11	May 3	May 29	June 22
5 years in 10, later than.	Mar. 29	Apr. 20	May 15	June 10
Fall:				
1 year in 10, earlier than.	Oct. 14	Sept. 26	Sept. 5	Aug. 14
2 years in 10, earlier than.	Oct. 23	Oct. 5	Sept. 14	Aug. 23
5 years in 10, earlier than.	Nov. 9	Oct. 22	Oct. 1	Sept. 9

History

Crook County was formed in 1882 from a part of old Wasco County. It was named for George Crook, a major general in the U.S. Army and an early pioneer and ex-

TABLE 15.—*Percentage of time, for a 12-month period, that wind velocity falls within given velocity ranges*

[Data based on hourly observations at Redmond Airport, Deschutes County, during a period of 4½ years]

Month	Velocity in miles per hour						
	0	1 to 3	4 to 7	8 to 12	13 to 18	19 to 24	25 to 38
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
January	8	4	34	23	21	7	3
February	14	5	42	19	15	3	1
March	9	6	43	21	17	4	(1)
April	10	6	43	21	16	3	(1)
May	11	6	43	24	14	2	(1)
June	12	9	39	26	13	1	(1)
July	10	5	47	26	11	1	(1)
August	10	6	50	25	8	1	(1)
September	14	6	48	23	7	1	(1)
October	11	8	48	21	10	2	1
November	11	6	41	24	16	1	1
December	12	5	38	23	17	3	1

[1] Less than 0.5 percent.

plorer. At one time the county consisted of the territory that is now Crook, Wheeler, Jefferson, and Deschutes Counties, and it had a total area of 6,068,560 acres. The county later was subdivided to form Wheeler County in 1899, Jefferson County in 1914, and Deschutes County in 1916.

The city of Prineville was named for Barney Prine, who had established a claim near the confluence of Ochoco Creek and the Crooked River. Prineville was built near the site of the claim and was incorporated by the State legislature in 1880.

The agricultural history of the county is one of livestock and grazing. Although farming became more diversified when irrigation water was made available in 1914, and after roads and transportation systems were improved, agriculture still is geared to the raising of livestock and the production of alfalfa hay and irrigated pasture. Small grain and potatoes are important cash crops. A common system of diversified farming consists of livestock, hay, and potatoes.

TABLE 16.—*Average relative humidity by month and time of day*

[Based on records at Redmond Airport, Deschutes County]

Month	Time of day			
	4:00 a.m.	10:00 a.m.	4:00 p.m.	10:00 p.m.
	Percent	*Percent*	*Percent*	*Percent*
January	74	64	62	74
February	80	64	54	77
March	75	52	44	66
April	72	39	32	61
May	77	43	34	64
June	80	44	35	61
July	74	32	22	49
August	72	38	29	55
September	70	38	28	54
October	79	50	42	67
November	75	59	54	73
December	79	67	66	82
Year	75	49	42	65

Population

According to the U.S. Census of Population, the total population of the county was 9,430 in 1960. About half this number lived in or near Prineville, and possibly three-fourths lived within the survey area. In 1960, the city of Prineville, the principal city and county seat, had a population of 3,263. The community of Prineville Southeast had a population of 1,299.

Transportation and Markets

The Area is well supplied with all-weather, surfaced or gravel roads. The City of Prineville operates a shortline railroad that connects the Area with major railroads. U.S. Highway No. 26, running east and west, passes through Prineville and connects with U.S. Highway No. 97, a principal highway crossing the State in a north-south direction. Daily bus and airline services are provided. Trucking lines maintain fast, reliable service to points within and outside the State.

Portland is the chief market for livestock, potatoes, and grain. The Willamette Valley is the principal market for hay.

Water Supply

The sources of water on farms in the Prineville Area are wells, streams, and ditches used for irrigation. East of the Crooked River, wells supply the only water for human use, and streams furnish water for irrigation. In the valley at Prineville there are artesian wells that supply water of generally satisfactory quality. On the basaltic upland plateau west of the Crooked River, the water used for irrigation is also used for livestock and domestic purposes. In this area the domestic supply is stored in cisterns and generally is chlorinated.

Wells have been drilled through the massive basaltic lava flows in the area of Powell Butte, but only a few of these were successful before 1956. Later the number of successful wells increased enough to supply adequate water for domestic use. In the Powell Butte area, water used for irrigation, livestock, and domestic purposes is carried in irrigation canals of the Central Oregon Irrigation District. These canals bring an adequate supply of good water from snow melting high on the east slopes of the Cascade Mountains, some 50 miles away.

Land Use

In Crook County, 72,228 acres are classified as cultivated land, 1,231,095 acres are grazing land, and 592,810 acres are timberland. About 55,100 acres of the arable soils in the county are irrigated, and about three-fourths of this acreage is in the survey area. Of the irrigated acreage, 23,400 acres are managed by irrigation districts, and 31,700 acres are under private management. About 17,128 acres in the county are dryfarmed, but most dryfarming is outside the survey area.

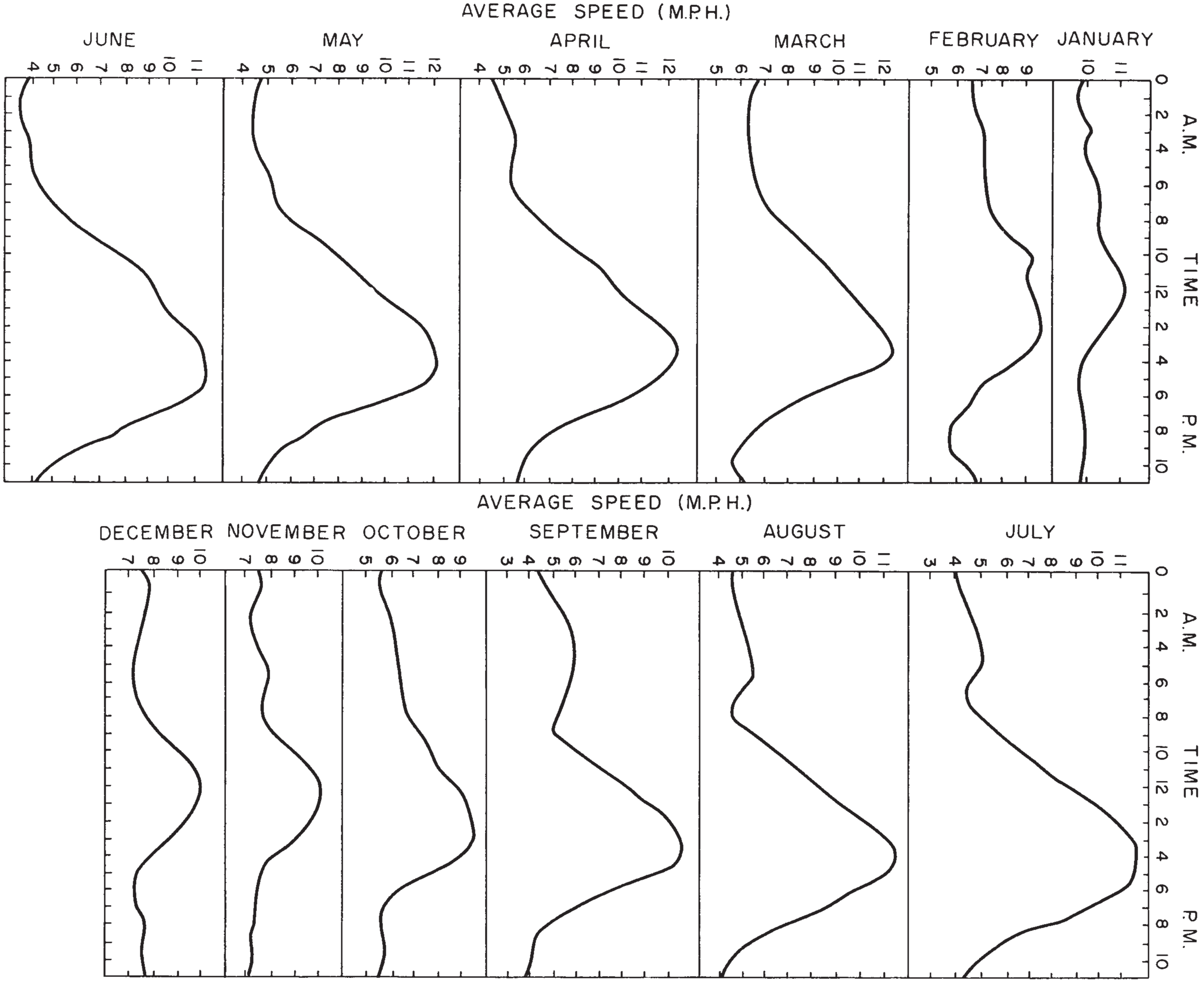

Figure 12.—Average hourly wind velocities, by months, on the Deschutes Plateau.

Of the total acreage grazed, 733,238 acres are privately owned, and 497,857 acres are chiefly in the public domain and partly in State or county ownership. Of the total acreage of timberland, 129,978 acres are privately owned, and 462,832 acres are in national forest.

Type and Size of Farms

Although the exact number of farms in the Prineville Area is not known, it is estimated that the Area has three-fourths of the total irrigated cropland in the county. According to the U.S. Census of Agriculture, the farms in the county average 2,639 acres in size. In this Area the average-size farm in the irrigated communities of Powell Butte, Lone Pine, and Prineville is about 120 acres.

Livestock

In 1954, about 51.2 percent of the total agricultural income in Crook County, excluding income from timber sales, was derived from the sale of livestock and livestock products. Livestock in the county number more than 50,000 beef cattle, 2,000 dairy cattle, 15,000 sheep, 2,000 hogs, and 2,200 horses.

The Ochoco National Forest annually furnishes pasture for about 15,000 sheep and 20,000 cattle. Much of the rangeland outside the national forest, including range administered by the U.S. Bureau of Land Management, furnishes pasture for about 35,000 cattle.

Crook County is among the important livestock-feeding districts in the State. The animals are fed hay, grain, and cull potatoes grown locally. In summer many of the cattle graze on the national forest or on irrigated pasture in the survey area.

For almost 100 years, the raising of beef cattle has been the major agricultural enterprise in the county. Soils in the survey area have been used mainly for producing hay to supply feed in winter and for growing supplemental pasture in summer. The principal breeds of cattle are Hereford, Shorthorn, and Angus. Cattle are sold to local buyers and then shipped to Portland. Because of the increase in acreage and production of alfalfa, feeding dry hay to feeder calves is now common.

Many small flocks of sheep are kept on irrigated farms. The Area is important in winter as a feeding area for bands of sheep that graze on the national forest in summer. The most common breeds of sheep are Rambouillet, Columbia, and Hampshire.

Crops

Table 17 gives the acreage and production of the principal crops, based on the U.S. Census of Agriculture. Because the survey area contains most of the irrigated soils in the county, the figures listed for crops grown under irrigation—alfalfa, potatoes, small grain, pasture, and others—are acceptable for the area surveyed.

The principal crops grown in the Prineville Area, in order of decreasing total acreage, are alfalfa for hay, grasses and legumes for irrigated pasture, wheat for grain, barley for grain, and potatoes. Somewhat less important cash crops are small grain for hay, oats for grain, rye for grain, mixed hay, and wild hay. Also grown are strawberries, berries, and onions, and alfalfa, potatoes, clover, and grass for seed.

Alfalfa.—Since 1914 there has been a steady though fluctuating increase in the acreage of alfalfa. This is the principal hay crop in the Area and is grown throughout the irrigated part. The average yield is about 3 tons per acre, but 4 to 6 tons per acre are common. Alfalfa generally follows small grain in a 6- to 8-year rotation that consists of potatoes for 1 or 2 years, small grain for 1 year, and alfalfa for 4 or 5 years. Because soils in the Area generally are deficient in sulfur, applying sulfur in the form of gypsum is a common practice. Adding phosphorus increases yields. The Ladak and Ranger varieties are superior to either common or Grimm, and the Orestan variety shows promise. Most of the alfalfa cut for hay is baled and stacked in the field, but some is chopped. Two cuttings, and occasionally three, are obtained each year. Most of the hay is fed on the farm, but 10 to 20 percent of it is shipped out of the county, mainly to dairy farms in the Willamette Valley.

Potatoes.—Following improvement in transportation in the survey area, potatoes became one of the chief cash crops. The City of Prineville Railroad, which connects Prineville with the major railroads, handles most of the shipping. Potatoes are grown on most of the irrigated soils in the survey area, but their position in the economy is not quite so high as in adjoining Deschutes and Jefferson Counties.

Although yields of potatoes vary considerably because of differences in soil characteristics and management, the average yield under good management is about 400 bushels per acre. Yields are slightly higher on the high terraces and alluvial fans north of Prineville than in the community of Powell Butte and, because of freezes late in spring and early in fall, they are lower on the sandy soils in Dry River Canyon. Growing potatoes on many of the bottom lands is not feasible, because drainage is not adequate.

Potatoes are not produced commercially on dryland soils. On irrigated soils they are commonly grown in a rotation with 2 to 5 years of alfalfa, pasture, or clover. Potatoes can be grown in the same field 2 years in succession if a green-manure crop is used. The potatoes are planted by machine in May and are placed 9 to 12 inches apart in rows that are 30 inches apart. The average rate of planting is 16 to 20 sacks of seed potatoes per acre. Generally a complete fertilizer is applied at a rate per acre of 100 pounds of nitrogen, 75 pounds of phosphoric acid (P_2O_5), 75 pounds of potash (K_2O), and 300 pounds of gypsum. Irrigation is by the furrow method, but the amount and rate of irrigation are highly variable. Experimental data on the water requirements of potatoes indicate that 12 to 16 acre-inches of water are needed for a crop. However, three to four times that amount is commonly used. On many farms potatoes are stored in cellars until they are graded and sold. Among the common varieties are the Netted Gem and Russett Burbank. Producing potatoes for certified seed is a profitable and specialized enterprise that has increased in importance since 1940.

Small grain.—Most of the wheat is grown on irrigated soils, but some is on nonirrigated soils near Grizzly

TABLE 17.—*Acreage and production of principal crops in Crook County, Oreg.*

Crop	1949		1954		1959	
Wheat, threshed or combined:	*Acres*	*Bu.*	*Acres*	*Bu.*	*Acres*	*Bu.*
Winter wheat	887	16, 924	2, 894	132, 950	1, 569	68, 757
Spring wheat	2, 854	54, 293	1, 511	50, 131	775	25, 001
Barley, threshed or combined	6, 248	260, 411	3, 942	178, 191	3, 054	114, 297
Oats, grown alone, threshed or combined	2, 167	77, 243	1, 172	44, 811	893	42, 564
		Tons		*Tons*		*Tons*
Hay crops, total	30, 656	48, 261	34, 794	667, 623	37, 329	71, 689
Alfalfa and alfalfa mixtures cut for hay	8, 826	20, 575	12, 822	38, 775	13, 310	39, 434
Clover, timothy, and mixture of clover and grasses cut for hay	656	1, 097	1, 684	3, 290	3, 117	6, 025
Oats, wheat, barley, rye, or other small grain cut for hay	11, 313	14, 787	10, 933	13, 450	6, 996	8, 678
Wild hay cut	8, 601	10, 148	8, 416	11, 405	10, 365	12, 923
Other hay cut	1, 260	1, 654	939	703	3, 541	4, 629
Seed:		*Lb.*		*Lb.*		*Lb.*
Alfalfa	5	761	10	600	(1)	(1)
Red clover	195	24, 053	60	12, 300	16	1, 000
Austrian winter peas	219	362, 743	10	6, 000	(1)	(1)
Ladino clover	415	60, 868	80	10, 000	(1)	(1)
Alsike clover	485	86, 524	500	117, 174	212	52, 500
Potatoes	4, 125	96, 533, 900	2, 581	64, 908, 800	2, 216	52, 303, 800

[1] Not reported.

Butte and on the alluvial fans above Mill Creek. Irrigated wheat follows potatoes in the rotation in order to obtain use of the fertilizer carried over from the potato crop. At times wheat is planted in spring as a nurse crop for legumes, though yields generally are 20 to 30 percent lower than if wheat is used alone. Barley and oats also are grown in rotation with potatoes and alfalfa and are commonly used as nurse crops for legumes.

Clover.—On irrigated soils in the Area, alsike and Ladino clovers grown for seed are important cash crops. Yields range from 200 to 800 pounds of seed per acre. Experimental tests have shown that 1,000 pounds of clean seed could be harvested per acre if harvesting methods were more efficient. Fertilization is about the same for clover as for alfalfa.

Irrigated pasture.—Irrigated pasture is chiefly on soils that are shallow, stony, sloping, steep, or imperfectly drained. On the stony soils, most permanent pasture that is irrigated consists of bluegrass and white clover. On the better soils, irrigated pasture is commonly grown in a 6- to 8-year rotation. Commonly seeded is a mixture of alta fescue or orchardgrass and clover; alta fescue, orchardgrass, and alfalfa; or alta fescue, meadow foxtail, and clover. Nitrogen, sulfur, and phosphate fertilizers are used at an annual rate per acre of about 120 pounds of nitrogen, 50 pounds of sulfur, and 50 pounds of phosphate. The time of application is important in obtaining the best growth. A split application is most suitable—half before April 1 and half about June 1.

Rangeland

Most areas of rangeland are covered mainly by big sagebrush, bunchgrasses, cheatgrass, and juniper. On much of the acreage there is considerable rabbitbrush that has invaded abandoned cropland and overgrazed range. In the eastern foothills, bitterbrush and such bunchgrasses as Idaho fescue and bluebunch wheatgrass occur with big sagebrush. Ponderosa pine, bitterbrush, and bunchgrasses are in the Ochoco Mountains. The principal grasses in the Prineville Area are bluebunch wheatgrass, Idaho fescue, needlegrasses, and Sandberg bluegrass.

A large part of the range is in poor condition because cheatgrass and rabbitbrush have replaced the more palatable grasses and brush. Wet meadows have been fertilized in some places, and crested wheatgrass has been planted in some range areas. The range is commonly grazed in spring and fall under a system of rotation-deferred grazing that helps in reestablishing and maintaining the perennial grasses.

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Glossary

Aggregate, soil. Many fine soil particles held in a single mass or cluster, such as a clod, crumb, block, or prism.

Alkali soils. Generally, a highly alkaline soil. Specifically, a soil that has so high a degree of alkalinity (pH 8.5 or higher), or so high a percentage of exchangeable sodium (15 percent or higher), or both, that the growth of most crop plants is reduced.

Alkaline soil. Generally, a soil that is alkaline throughout most or all of that part of it occupied by plant roots, but the term is commonly applied to only a specific layer or horizon of a soil. Precisely, any soil horizon having a pH value greater than 7.0; practically, a soil having a pH above 7.3.

Alluvial fan. Soil material laid down by water in a fan- or cone-shaped deposit at the base of a mountain.

Alluvium. Soil materials deposited on land by streams.

Bottom land. Nearly level land occupying the bottom of the valley of a present stream and subject to flooding unless protected artificially.

Calcareous soil. A soil containing enough calcium carbonate (commonly with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Cementation (soil materials). A brittle, hardened consistence caused by a cementing substance other than clay minerals, such as lime, silica, iron, or alumina. Typically, the cementation is changed little if any by moistening, and the hardness or brittleness persists in the wet condition. Some cementing agents resist moistening but soften under prolonged wetting and give rise to soil layers in which the cementation is strong when dry but is very weak when wet. Some layers cemented with lime soften readily upon wetting. Unless otherwise stated, cementation descriptions imply little alteration, if any, by wetting. Relative terms used are as follows:

Weakly cemented.—Cemented mass is brittle and hard, but it can be broken in the hands.

Strongly cemented.—Cemented mass is brittle and hard; it cannot be broken in the hands but is easily broken with a hammer.

Indurated.—Very strongly cemented, brittle; does not soften under prolonged wetting and is so extremely hard that a sharp blow with a hammer is required for breakage; hammer generally rings as a result of the blow.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Some of the terms commonly used to describe consistence are—

Loose.—Noncoherent; soil does not hold together in a mass.

Friable.—When moist, soil crushes easily under gentle pressure between thumb and forefinger and can be pressed together in a lump.

Firm.—When moist, soil crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, soil is readily deformed by moderate pressure but can be pressed into a lump; forms a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, soil adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, soil is moderately resistant to pressure but is difficult to break between thumb and forefinger.

Soft.—When dry, soil breaks into powder or individual grains under very slight pressure.

Drainage, soil. (1) The rapidity and extent of the removal of water from the soil by runoff and flow through the soil to underground spaces. (2) As a condition of the soil, soil drainage refers to the frequency and duration of periods when the soil is free of saturation. For example, in well-drained soils, the water is removed readily but not rapidly; in poorly drained soils, the root zone is waterlogged for long periods and the roots of ordinary crop plants cannot get enough oxygen; and in excessively drained soils, the water is removed so completely that most crop plants wither from lack of water.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes and that differs in one or more ways from adjacent horizons in the same profile.

Inclusions. Areas of soil that are too small to be shown separately on a map of the scale used and are, therefore, mapped with a soil of a different type or phase.

Irrigability. The relative ease or difficulty of leveling and grading the soil and distributing irrigation water. The terms used in this report are: *Very easy, easy, slightly difficult, difficult, very difficult,* and *not suitable.*

Leaching. The removal of material in solution by water passing through soil.

Lime. Lime from the strictly chemical standpoint refers to only one compound, calcium oxide (CaO). However, the term lime is commonly used in agriculture to include a great variety of materials that are generally composed of the oxide, hydroxide, or carbonate of calcium, or of calcium and magnesium. The most commonly used forms of agricultural lime are ground limestone (carbonates), hydrated lime (hydroxides), burnt lime (oxides), marl, and oystershells.

Loam. Soils that contain 7 to 27 percent clay, 23 to 50 percent silt, and less than 52 percent sand.

Moisture-holding capacity. The capacity of the soil to hold moisture that will not drain away but that can be taken up by plant roots. Relative terms are *low, moderate, high,* and *very high.*

Mottled. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.*

Pan. A layer in a soil that is firmly compacted or very rich in clay. Frequently the word "pan" is combined with other words that more explicitly indicate the nature of the layers, for example, *hardpan, claypan,* and *traffic pan.*

Parent material (soil). The horizon of weathered rock or partly weathered soil material from which soil has formed.

Permeability, soil. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material. (See also Horizon, soil.)

Pumice. An excessively cellular, glassy lava, generally of the composition of rhyolite. It is a sort of volcanic froth, generally whitish or grayish in color, that is very light and will float on water.

Pumiceous soil. Soil that has developed from pumice.

Reaction, soil. The degree of acidity or alkalinity of the soil, expressed in pH values or in words, as follows:

	pH		*pH*
Extremely acid	Below 4.5	Mildly alkaline	7.4 to 7.8
Very strongly acid	4.5 to 5.0	Moderately alkaline	7.9 to 8.4
Strongly acid	5.1 to 5.5	Strongly alkaline	8.5 to 9.0
Medium acid	5.6 to 6.0	Very strongly alkaline	9.1 and higher
Slightly acid	6.1 to 6.5		
Neutral	6.6 to 7.3		

Runoff. The removal of water by flow over the surface of the soil. The amount and rapidity of surface runoff are affected by the texture, structure, and porosity of the surface layer, by the vegetative covering, by the prevailing climate, and by the slope. The rate of surface runoff is expressed as follows: *Ponded, very slow, slow, medium, rapid,* and *very rapid.*

Sand. (1) Individual rock or mineral fragments having diameters ranging from 0.05 millimeter to 2.0 millimeters. Sand grains consist chiefly of quartz, but they may be of any mineral composition. (2) As a soil textural class, soil that is 85 percent or more sand and not more than 10 percent clay.

Silt. (1) Individual mineral particles of soil that range in diameter from 0.002 millimeter to 0.05 millimeter. (2) As a textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Slope, soil. The incline of the surface of a soil. It is usually expressed in percentage of slope, which equals the number of feet of fall per 100 feet of horizontal distance. The slope classes used in this report are:

	Percent		*Percent*
Nearly level	0 to 2	Moderately sloping	12 to 20
Gently sloping	2 to 6	Steep	20 to 40
Sloping	6 to 12	Very steep	40 to 70

Sodic soil. A soil containing a harmful concentration of sodium.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate, and living matter acting on parent material, as conditioned by relief over periods of time.

Stripcropping. Growing crops in a systematic arrangement of strips, or bands, to serve as vegetative barriers to wind or water erosion.

Structure, soil. The arrangement of primary soil particles into compound particles, or clusters, that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*blocky, columnar, granular, platy,* and *prismatic.* Structureless soils are single grain (each grain by itself, as in dune sand) or massive (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Angular blocky.—Aggregates are shaped like blocks; they may have flat or rounded surfaces that join at sharp angles.

Subangular blocky.—Aggregates have some rounded and some flat surfaces; upper sides are rounded.

Columnar.—Aggregates are prismatic and are rounded at the top.

Granular.—Aggregates are roughly spherical, small, and relatively nonporous, but they do not have the distinct faces of blocky structure.

Platy.—Aggregates are flaky or platelike.

Prismatic.—Aggregates have flat vertical surfaces, and their height is greater than their width.

Subsoil. In many soils, the B horizon; roughly, the part of the profile below plow depth and above the parent material.

Surface soil. Technically, the A horizon; commonly, the upper part of arable soils stirred by tillage implements, or an equivalent depth (5 to 8 inches) in nonarable soils.

Terrace (geology). A nearly level or gently undulating plain that occurs along a stream valley and is intermediate in elevation between the flood plain and the upland. Terraces are remnants of an earlier flood plain of the stream.

Texture, soil. The relative proportions of the various size groups of individual soil grains in a mass of soil; specifically, the proportions of sand, silt, and clay. (See also Sand, Silt, and Clay.)

Underlying material. Any layer beneath the solum, or true soil. It applies to the parent material and to layers unlike the parent material that lie below the B horizon, or subsoil.

Upland (geology). Land consisting of material unworked by water in recent geologic time and generally at a higher elevation than the alluvial plain or stream terrace; land above the lowlands along rivers or between hills.

Vesicular. Having many holes or air pockets (like a sponge). Characteristic of the pumice and basalt in the Prineville Area.

Workability. The relative ease or difficulty of tilling the soil and harvesting the crops. The terms used in this report are: *Very easy, easy, slightly difficult, difficult, very difficult,* and *impractical.*

U.S. GOVERNMENT PRINTING OFFICE: 1966

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United States
Department of
Agriculture

Natural
Resources
Conservation
Service

In cooperation with
United States Department
of Agriculture, Forest
Service; United States
Department of the Interior,
Bureau of Land
Management; and Oregon
Agricultural Experiment
Station

Soil Survey of Upper Deschutes River Area, Oregon, including parts of Deschutes, Jefferson, and Klamath Counties

https://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/oregon/OR620/0/or620_text.pdf

How to Use This Soil Survey

General Soil Map

The general soil map, which is a color map, shows the survey area divided into groups of associated soils called general soil map units. This map is useful in planning the use and management of large areas.

To find information about your area of interest, locate that area on the map, identify the name of the map unit in the area on the color-coded map legend, then refer to the section **General Soil Map Units** for a general description of the soils in your area.

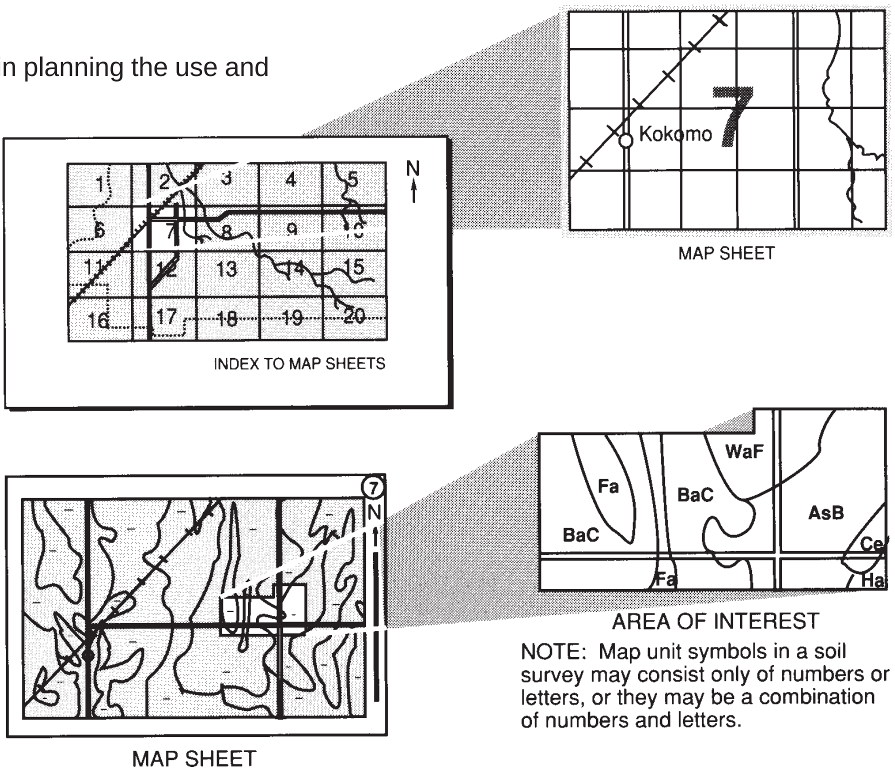
Detailed Soil Maps

The detailed soil maps can be useful in planning the use and management of small areas.

To find information about your area of interest, locate that area on the **Index to Map Sheets**. Note the number of the map sheet and turn to that sheet.

Locate your area of interest on the map sheet. Note the map unit symbols that are in that area. Turn to the **Contents**, which lists the map units by symbol and name and shows the page where each map unit is described.

The **Contents** shows which table has data on a specific land use for each detailed soil map unit. Also see the **Contents** for sections of this publication that may address your specific needs.



NOTE: Map unit symbols in a soil survey may consist only of numbers or letters, or they may be a combination of numbers and letters.

This soil survey is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (formerly the Soil Conservation Service) has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in 1990. Soil names and descriptions were approved in 1992. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1992. This survey was made cooperatively by the Natural Resources Conservation Service and the Forest Service, Bureau of Land Management, and Oregon Agricultural Experiment Station. The survey is part of the technical assistance furnished to the Deschutes County, Jefferson County, and Klamath County Soil and Water Conservation Districts. Assistance was provided by the Board of Commissioners for Deschutes and Jefferson Counties.

Since the publication of this survey, more information on soil properties may have been collected, new interpretations developed, or existing interpretive criteria modified. The most current soil information and interpretations for this survey are in the Field Office Technical Guide (FOTG) at the local office of the Natural Resources Conservation Service. The soil maps in this publication may exist in digital form in a full quadrangle format. The digitizing of the maps is in accordance with the Soil Survey Geographic (SSURGO) database standards. During the digitizing process, changes or corrections to the maps may have occurred. These changes or corrections improve the matching of this survey to adjacent surveys and correct previous errors or omissions of map unit symbols or lines. If digital SSURGO-certified maps exist for this survey, they are considered the official maps for the survey area and are part of the FOTG at the local office of the Natural Resources Conservation Service.

Soil maps in this survey may be copied without permission. Enlargement of these maps, however, could cause misunderstanding of the detail of mapping. If enlarged, maps do not show the small areas of contrasting soils that could have been shown at a larger scale.

Cover: Riparian habitat and rangeland along the Crooked River.

Additional information about the Nation’s natural resources is available on the Natural Resources Conservation Service home page on the World Wide Web. The address is http://www.nrcs.usda.gov (click on “Technical Resources”).

Contents

Issued 1999

Foreword

This soil survey contains information that affects land use planning in this survey area. It contains predictions of soil behavior for selected land uses. The survey also highlights soil limitations, improvements needed to overcome the limitations, and the impact of selected land uses on the environment.

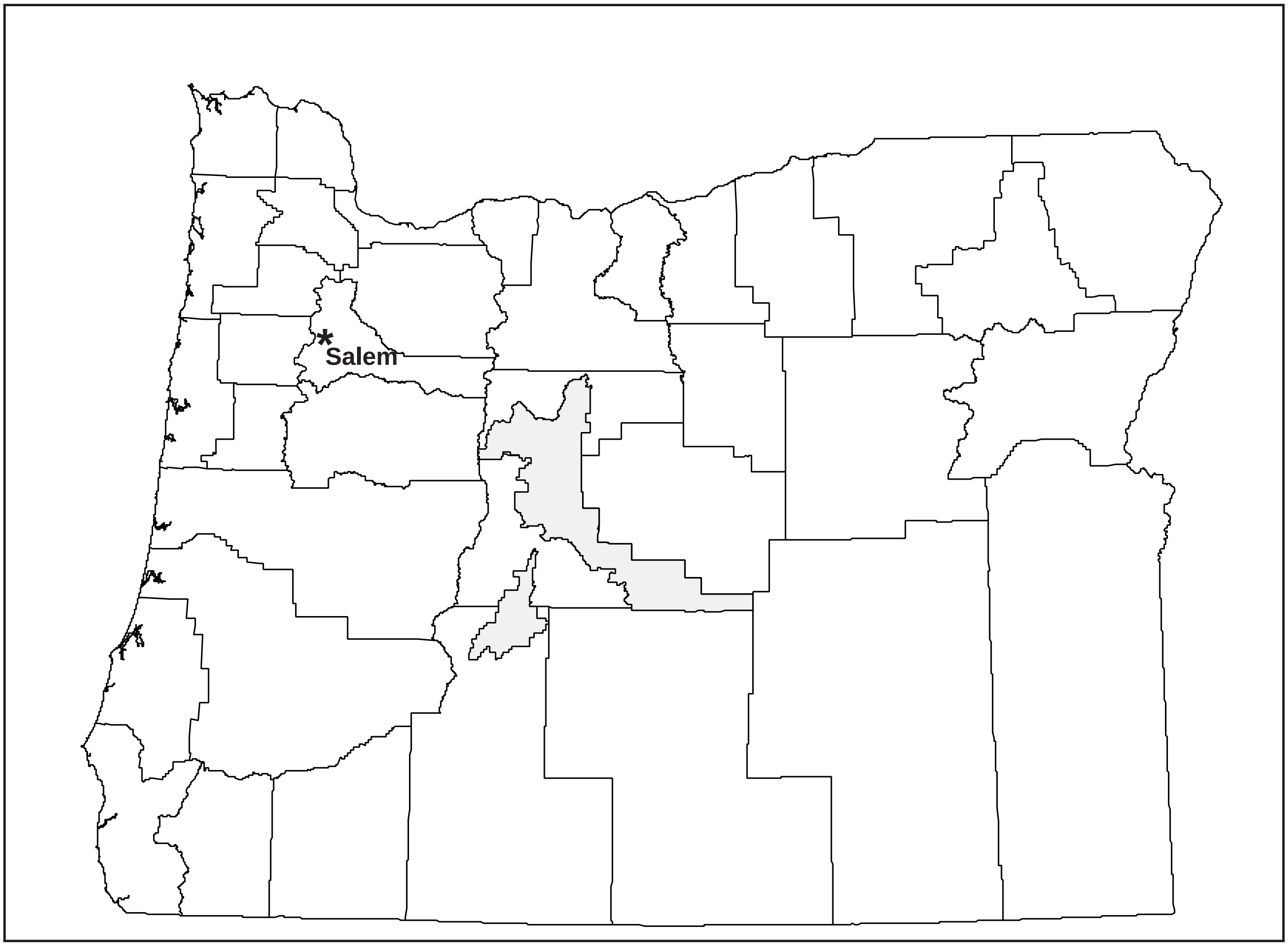
This soil survey is designed for many different users. Farmers, ranchers, foresters, and agronomists can use it to evaluate the potential of the soil and the management needed for maximum food and fiber production. Planners, community officials, engineers, developers, builders, and home buyers can use the survey to plan land use, select sites for construction, and identify special practices needed to ensure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use the survey to help them understand, protect, and enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. The information in this report is intended to identify soil properties that are used in making various land use or land treatment decisions. Statements made in this report are intended to help the land users identify and reduce the effects of soil limitations that affect various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are shallow to bedrock. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

These and many other soil properties that affect land use are described in this soil survey. Broad areas of soils are shown on the general soil map. The location of each soil is shown on the detailed soil maps. Each soil in the survey area is described. Information on specific uses is given for each soil. Help in using this publication and additional information are available at the local office of the Natural Resources Conservation Service or the Cooperative Extension Service.

Bob Graham
State Conservationist
Natural Resources Conservation Service



Location of Upper Deschutes River Area in Oregon.

Soil Survey of Upper Deschutes River Area, Oregon, including parts of Deschutes, Jefferson, and Klamath Counties

By Ron Myhrum and William Ferry, Natural Resources Conservation Service

Fieldwork by William Ferry, Mike Lamkin, Jerry Macdonald, Ron Myhrum, and Aimee Walker, Natural Resources Conservation Service; Terry Brock, Forest Service; and Larry Thomas, Bureau of Land Management

United States Department of Agriculture, Natural Resources Conservation Service,
in cooperation with
United States Department of Agriculture, Forest Service; United States Department of the Interior, Bureau of Land Management; and Oregon Agricultural Experiment Station

The UPPER DESCHUTES RIVER AREA includes private and public land in parts of Deschutes, Jefferson, and Klamath Counties. The northern part of the survey area is comprised of the western part of Jefferson County (excluding the Warm Springs Indian Reservation). The central part of the survey area is in Deschutes County, and it includes areas of land administered by the Forest Service and the Bureau of Land Management. The southern part of the survey area is an island comprised of the southern part of Deschutes County, near LaPine, extending into the northern part of Klamath County and south to Crescent and Gilchrist. The survey area includes about 1,540,000 acres.

A wide variety of landscapes make up the survey area. In the north is the plateau known as the Agency Plains, adjacent to the Deschutes River canyon. To the south are rolling hills and lava benches with deep gorges incised by the Deschutes and Crooked Rivers. Farther to the south are pumice flats and basins with scattered cinder cones. To the east are the basalt plateaus of the high desert. The western edge is made up of the glaciated toe slopes and valleys of the Cascade Mountains. Elevation ranges from 1,295 feet at the northernmost point in the survey area to 5,545 feet at Three Creek Butte. The average annual precipitation is about 8 to 70 inches.

The survey area includes almost all of the cultivated land in Jefferson and Deschutes Counties and the major population centers in these counties. Bend and Madras, the county seats of Deschutes and Jefferson Counties, respectively, are in the survey area.

Recreation and tourism, wood products, farming and ranching, and manufacturing are the main industries. The survey area is adjacent to or very near three wilderness areas, and there are two ski areas just to the west of the survey area. Several lakes, streams, and rivers are in or near the area.

The major north-south highway on the eastern side of the Cascade Mountains, U.S. Highway 97, passes through LaPine, Bend, Redmond, and Madras. A major east-west artery, U.S. Highway 20, passes through Bend and Sisters. A municipal airport is in Redmond, and airstrips with facilities are in Madras, Bend, and Sunriver. The railroad transects the area, following much the same route as U.S. Highway 97.

This soil survey updates the survey of Deschutes Area, Oregon, published in 1958 *(23)* and the interim survey of Brothers Area published in 1983 *(28)*. It provides additional information and has larger maps, which show the soils in greater detail.

General Nature of the County

This section briefly discusses the history and development, physiography and drainage, and climate of the survey area.

History and Development

When Europeans first saw the area of the Upper Deschutes River, it was occupied by the Warm Springs and Northern Paiute Tribes. Long before that time, Klamath Lakes Indians had occupied much of what is now the southern part of the survey area. The Molalla Indians from the Willamette Valley area west of the Cascade Mountains seasonally traveled into central Oregon and the Deschutes River area to gather food. The Cayuse and Sahaptin Indians also seasonally migrated into the area from the region that is now northeastern Oregon *(30)*.

A treaty was signed in 1955 that brought the Warm Springs, Paiute, and Wasco Tribes together on the Warm Springs Indian Reservation. The Warm Springs and Wasco Indians had been neighbors (the Wasco Indians occupied the region around The Dalles), had similar cultures, and often intermarried. Both tribes fished, hunted, and gathered roots and berries for sustenance.

The pursuit of beaver pelts brought the first white men to the area of the Deschutes River. “Deschutes” is from the French “Riviere des Chutes,” which means the river of the falls. The first white man to see the Upper Deschutes River and central Oregon was Peter Skene Ogden of the Hudson’s Bay Company. He and his party set out from the Columbia River late in 1825 and headed up the Deschutes River, trapping as they went. When they came to what is now known as the Crooked River, they ventured upriver, eventually arriving in the John Day River area. They returned in 1826, heading down the White River and crossing the Deschutes River at Sherar’s Falls. Again they headed up the Deschutes River to the Crooked River, and after following that channel, ventured into southeastern Oregon. On their return, they became the first white men to see what later became known as Newberry Crater, East Lake, and Paulina Lake *(6)*.

An exploration party under the command of Lt. Robert Williamson was sent west in 1855 to find the best route for a railroad to extend from the Mississippi River to the Pacific Ocean. Included in the party was John Strong Newberry, a physician and naturalist, whose name was given to the crater discovered in 1826. The expedition came from San Francisco by way of Klamath Falls. Their trek led them through the Deschutes River area, and they continued on to the Metolius River and Black Butte areas. They followed the Metolius River to the Cove Palisades and then crossed the Cascade Mountains.

Settlement in the area was discouraged, and in 1856 it was even forbidden by the Federal government because of resistance to the presence of white men. The area to the north and east was settled first, particularly that near Shaniko, which was the end of the line for the railroad.

The Homestead Act of 1862 drew many optimists to the area, and even the high desert to the east was scattered with homesteaders. One by one, however, these would-be ranchers and farmers surrendered the land back to the sagebrush and moved on.

The Madras area was settled in the late 1860’s. There was a rumor that a railroad was coming to this area, and settlers were drawn to the area because the soil was more fertile than that near Bend and Redmond.

Irrigation had several small beginnings in the 1870’s in the Sisters, Bend, Redmond, and Madras areas. Rights to water from the Deschutes River were filed in the 1890’s.

The ill-fated Tumalo Irrigation District was established in 1893, the Swalley Brothers Irrigation District in 1899, and the Arnold Irrigation District in 1904. The Pilot Butte Canal started carrying water in 1904, and it became part of the Central Oregon Irrigation District in 1910. In 1912 the North Canal began transporting water northward to Redmond. The Redmond area received irrigation water in 1906 and the Madras area in 1946. Presently, six irrigation districts use water from the Deschutes River.

Alfalfa, barley, oats, and potatoes were all grown in the earlier days in Deschutes and Jefferson Counties. Presently in Deschutes County, alfalfa is the main crop and there are relatively few acres of potatoes and mint. Almost all other irrigated land in the county is pasture. In Jefferson County, alfalfa, potatoes (mostly seed potatoes), grass seed, carrot seed, mint, and garlic are grown, making it a diverse and significant agricultural area.

Livestock in the survey area historically included only cattle and sheep. Today the livestock operations are comprised of cattle, llamas, horses, and sheep.

Timber land in the area has been bought since as early as 1898; however, until the railway was completed, the importance of lumber to the economy was limited. In 1916 the Shevlin-Hixon Mill was established, and the Brooks-Scanlon Mill was established soon after. According to Phil Brogan, by the late 1920’s these mills were producing 500 million board feet of lumber annually and they employed about 2,000 workers. This helped to establish the economic base for Bend and the rest of central Oregon *(7)*. In spite of reduced timber harvesting, the wood products industry is still important to the economy of Deschutes and Jefferson Counties.

The survey area is known for its recreational appeal. Central Oregon offers opportunities for world-class downhill and cross-county skiing, golfing, fishing, hunting, whitewater rafting, rock climbing, and hiking.

Physiography and Drainage

The approximately 1.5 million acres comprising the survey area includes parts of three major land resource areas—the Upper Snake River Lava Plains and Hills, the Eastern Slope of the Cascade Mountains, and the Malheur High Plateau *(27)*.

Relief is moderate throughout the survey area. The topography of the Upper Snake River Lava Plains and Hills resource area is nearly level to rolling except for the deeply incised canyons of the Deschutes and Crooked Rivers and several widely scattered cinder cones. With the exception of the Deschutes and Crooked Rivers, perennial and intermittent drainageways are lacking because of the limited precipitation and runoff.

The topography of the Eastern Slope of the Cascade Mountains resource area is nearly level to steep. Perennial and intermittent drainageways are numerous because of the precipitation that falls in spring and fall and the continuous runoff from snowmelt.

The topography of the Malheur High Plateau resource area is nearly level to rolling except for the numerous cinder cones that dot the landscape. Perennial and intermittent drainageways are lacking in this resource area because of limited precipitation and runoff.

Most of the survey area is drained by the Deschutes River and its tributaries, which include the Little Deschutes River, Tumalo Creek, Dry River, Squaw Creek, Metolius River, Crooked River, and Willow Creek. Water is a limited resource in the agricultural areas of the survey area because of the limited precipitation, high infiltration rate, and moderate or rapid permeability of the soils. Water from snowmelt is stored in Crane Prairie and Wickiup Reservoirs and is used for irrigation.

Climate

In this survey area, temperature and precipitation are related to changes in elevation. Elevation increases from the northern part of the area near Madras to the southern part near LaPine. The climate for the area was recorded at Madras, Bend, and Chemult during the period 1952 to 1990. The weather station at Chemult is outside the survey area, but the climate is representative of the LaPine area.

Table 1 gives data on temperature and precipitation. Table 2 shows probable dates of the first freeze in fall and the last freeze in spring. Table 3 provides data on length of the growing season.

The average monthly temperature at Madras, Bend, and Chemult is 48, 46, and 42 degrees F, respectively. The average temperature in summer (June, July, and August) is 64, 60, and 53 degrees, respectively. The average temperature in winter (December, January, and February) is 34, 33, and 28 degrees, respectively. The extreme temperatures at all three stations were about 102 degrees for the high and -27 degrees for the low.

Growing degree days, shown in table 1, are equivalent to “heat units.” During the month, growing degree days accumulate by the amount that the average temperature each day exceeds a base temperature (40 degrees). The normal monthly accumulation is used to schedule single or successive plantings of a crop between the last freeze in spring and the first freeze in fall.

The average annual precipitation is 11 inches at Madras and Bend and 24 inches at Chemult. Most of the precipitation, about 70 percent, falls during November through April. During the driest months, which are July, August, and September, the average monthly precipitation is less than 1 inch. The amount and duration of snowfall in winter is variable, but the southern part of the area receives the highest amounts for the longest duration.

How This Survey Was Made

This survey was made to provide information about the soils and miscellaneous areas in the survey area. The information includes a description of the soils and miscellaneous areas and their location and a discussion of their suitability, limitations, and management for specified uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They dug many holes to study the soil profile, which is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

The soils and miscellaneous areas in the survey area are in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept or model of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Data are assembled from other sources, such as research information, production records, and field experience of specialists.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Survey Procedures

The general procedures followed in making this survey are described in the National Soil Survey Handbook of the Natural Resources Conservation Service. Source material used in the development of the survey includes the soil survey of the Deschutes Area, Oregon, published in 1958 *(23)*; the interim soil survey of the Brothers Area published in 1983 *(28)*; U.S. Geological Survey geologic maps; and the National Cooperative Soil Survey memorandum of understanding between the Natural Resources Conservation Service, the Forest Service, the Bureau of Land Management, and the Oregon Agricultural Experiment Station.

By separating the landscapes into discrete landforms and identifying the dominant soil-forming properties on each landform, predictable soil-landform models became apparent and were the basis for the soil maps and the development of the soil series and map unit descriptions. The soil-landform relationships for this survey area are discussed under the heading “Formation of the Soils.”

The survey area was mapped at two levels of intensity. At the less detailed level, map units are mainly associations and complexes. The average size of the delineations for most management purposes was 160 acres. Most of the land mapped at this level is used as woodland and rangeland. At the more detailed level, map units are mainly consociations and complexes. The average size of the delineations for purposes of management was 40 acres, and the minimum size was 5 acres. Most of the land mapped at the more detailed level is used as irrigated and nonirrigated cropland. Spot symbols were used for contrasting soil types and miscellaneous areas that are too small to be mapped at the same intensity as the surrounding land. Inclusions of contrasting soils or miscellaneous areas are described in the map unit if they are a significant component of the unit.

Soil mapping in the high desert of eastern

Deschutes County and around the Cline Buttes area of western Deschutes County was completed by the Bureau of Land Management in the period 1978 to 1980. Some revision of the original series and map units occurred during this survey to reflect a better understanding of the soils. The Forest Service assisted in the soil mapping of the Sisters and Bend Ranger Districts in the Deschutes National Forest.

Samples for chemical and physical analysis were taken from typical pedons of the major soils in the survey area. The analyses were made at the National Soil Survey Laboratory in Lincoln, Nebraska, and at the Oregon State University laboratory. The analyses provided data used in soil classification and in making interpretations for fertility and erodibility and for engineering and land use planning.

Productivity estimates were made for timber production, rangeland, and crop production. Woodland productivity was estimated by the National Resources Conservation Service and the Forest Service from data gathered at selected forested sites. Rangeland productivity was estimated for plots inside and outside the survey area. Agricultural crop yield data was estimated by the Cooperative Extension Service, Farm Services Agency, and individual farmers.

General Soil Map Units

The general soil map at the back of this publication shows broad areas that have a distinctive pattern of soils, relief, and drainage. Each map unit on the general soil map is a unique natural landscape. Typically, it consists of one or more major soils or miscellaneous areas and some minor soils or miscellaneous areas. It is named for the major soils or miscellaneous areas. The components of one map unit can occur in another but in a different pattern.

The general soil map can be used to compare the suitability of large areas for general land uses. Areas of suitable soils can be identified on the map. Likewise, areas where the soils are not suitable can be identified.

Because of its small scale, the map is not suitable for planning the management of a farm or field or for selecting a site for a road or building or other structure. The soils in any one map unit differ from place to place in slope, depth, drainage, and other characteristics that affect management.

Soils on Pumice-Mantled Stream Terraces and Flood Plains

This group consists of one map unit. It makes up about 3 percent of the survey area.

1. Tutni-Sunriver-Cryaquolls

Very deep, somewhat poorly drained to very poorly drained soils that formed in mixed alluvium high in content of ash and in ash and pumice over older alluvium

This map unit is on stream terraces and flood plains in LaPine Basin. Elevation ranges from 4,000 to 5,000 feet. Slopes range from 0 to 3 percent. The mean annual precipitation is 18 to 25 inches, the mean annual air temperature is 40 to 44 degrees F, and the frost-free period is 10 to 50 days.

This unit makes up about 3 percent of the survey area. It is about 40 percent Tutni soils, 30 percent Sunriver soils, and 20 percent Cryaquolls. The rest is soils of minor extent.

Tutni soils are on stream terraces. These soils are more than 60 inches deep to bedrock and are somewhat poorly drained. They have a very dark grayish brown loamy coarse sand surface layer; a mottled, dark grayish brown very gravelly coarse sand substratum; and a very dark grayish brown sandy loam buried layer. Depth to a seasonal high water table is 18 to 48 inches.

Sunriver soils are on stream terraces. These soils are more than 60 inches deep to bedrock and are somewhat poorly drained. They have a very dark gray sandy loam surface layer; a mottled, light brownish gray coarse sand subsoil; and a mottled, very dark gray sandy loam buried layer. Depth to a seasonal high water table is 24 to 48 inches.

Cryaquolls are on flood plains. These soils are more than 60 inches deep to bedrock and are poorly drained and very poorly drained. They have a dark brown silt, silt loam, or gravelly loamy sand surface layer; a very dark gray, mottled sandy loam, loam, silt loam, or loamy sand subsoil; and a very dark gray sand substratum. A seasonal high water table is at the surface to a depth of 24 inches below the surface. These soils are subject to rare flooding.

Of minor extent in this unit are Wickiup soils on stream terraces.

This unit is used mainly as wildlife habitat and pasture and for timber production.

The cold climate of the LaPine Basin and a seasonal high water table restrict these soils for most uses. Lodgepole pine is the principal tree species on the Tutni and Sunriver soils. The seasonal high water table restricts equipment use to summer and increases the risk of windthrow. Designated skid trails should be established to minimize soil compaction. Seedlings adapted to droughtiness in summer should be planted. Soil displacement should be minimized because fertility is highest in the organic layer and the upper mineral layers. Cryaquolls support lush wetland vegetation and are primarily used as wildlife habitat. Some areas are used as native pasture.

The soils in this unit are poorly suited to use as building sites. The seasonal high water table restricts the installation of standard septic systems. Because of the cold soil temperatures and the coarse texture of the soil material, morphological evidence of seasonal wetness is minimal.

Soils on Pumice-Mantled Lava Plains and Hills

This group consists of two map units. It makes up about 15 percent of the survey area.

2. Shanahan-Steiger

Very deep, somewhat excessively drained soils that formed in ash and pumice over colluvium and older alluvium

This map unit is on lava plains and hills in the LaPine Basin. Elevation ranges from 4,000 to 6,000 feet. Slopes range from 0 to 50 percent, but they dominantly are less than 15 percent. The mean annual precipitation is 18 to 25 inches, the mean annual air temperature is 40 to 44 degrees F, and the frost free period is 10 to 50 days.

This unit makes up about 7 percent of the survey area. It is about 50 percent Shanahan soils and 45 percent Steiger soils. The rest is soils of minor extent.

Shanahan soils are more than 60 inches deep to bedrock and are somewhat excessively drained. These soils have a dark brown loamy coarse sand surface layer, a yellowish brown and brown loamy coarse sand and coarse sand substratum, and a dark brown sandy loam and gravelly sandy loam buried layer. Depth to the buried layer is 20 to 40 inches.

Steiger soils are more than 60 inches deep to bedrock and are somewhat excessively drained. These soils have a dark grayish brown loamy coarse sand surface layer, a pale yellow gravelly coarse sand substratum, and a dark yellowish brown loam buried layer. Depth to the buried layer is 40 to 60 inches or more.

Of minor extent in this unit are Sunriver and Tutni soils on pumice-mantled stream terraces.

This unit is used mainly for timber production and as wildlife habitat.

Lodgepole pine is the dominant tree species in the low, nearly level positions on lava plains, where frost pockets occur. Ponderosa pine is dominant in the higher positions on lava plains, where the risk of frost is lower. Mixed conifers, including ponderosa pine, sugar pine, white fir, and Douglas fir, are on the hills along the western margin of the basin. Windthrow is a hazard because of the coarse texture of the ash and pumice. Practices that minimize soil displacement, compaction, and erosion should be used, especially in the steeper areas.

3. Lapine

Very deep, excessively drained soils that formed in pumice and ash

This map unit is on lava plains and hills in the LaPine Basin. Elevation ranges from 4,200 to 6,000 feet. Slopes range from 0 to 70 percent, but they dominantly are less than 15 percent. The mean annual precipitation is 18 to 25 inches, the mean annual air temperature is 40 to 44 degrees F, and the frost-free period is 10 to 50 days.

This unit makes up about 8 percent of the survey area. It is about 90 percent Lapine soils. The rest is soils of minor extent.

Lapine soils are more than 60 inches deep to bedrock and are excessively drained. These soils have a very dark grayish brown and dark brown gravelly loamy coarse sand surface layer and a very pale brown and light gray gravelly to extremely gravelly coarse sand substratum.

Of minor extent in this unit are Wickiup soils in depressions on stream terraces.

This unit is used mainly for timber production.

Lodgepole pine is the dominant tree species in the low, nearly level positions on lava plains, where frost pockets occur. Ponderosa pine is dominant in the higher positions, where the risk of frost is lower. Mixed conifers, including ponderosa pine, sugar pine, white fir, and Douglas fir, make up the overstory vegetation on the sloping uplands along the western margin of the basin and on Walker Rim. Windthrow is a concern because of the coarse texture of the ash and pumice. Practices that limit soil displacement, compaction, and erosion should be used, especially in the steeper areas. Dry ravel on the steeper slopes may damage seedlings.

Soils on Canyonsides

This group consists of one map unit. It makes up about 4 percent of the survey area.

4. Simas-Ruckles-Lickskillet

Very deep and shallow, well drained soils that formed in loess and colluvium

This map unit is on canyonsides of the Deschutes, Crooked, and Metolius Rivers. Elevation ranges from 1,400 to 3,500 feet. Slopes range from 15 to 80 percent. The mean annual precipitation is 9 to 12 inches, the mean annual air temperature is 47 to 52 degrees F, and the frost-free period is 110 to 140 days.

This unit makes up about 4 percent of the survey area. It is about 40 percent Simas soils, 30 percent Ruckles soils, and 15 percent Lickskillet soils. The rest is soils of minor extent.

Simas soils are more than 60 inches deep to bedrock and are well drained. They typically are on toe slopes and are associated with tuff. These soils have a dark grayish brown cobbly loam surface layer and a yellowish brown gravelly clay, cobbly clay, and clay subsoil.

Ruckles soils are 10 to 20 inches deep to bedrock and are well drained. They typically are on middle and upper side slopes and are associated with basalt. These soils have a dark grayish brown extremely cobbly loam surface layer and a brown extremely cobbly clay and cobbly clay subsoil.

Lickskillet soils are 12 to 20 inches deep to bedrock and are well drained. They typically are in the steepest areas of middle and upper side slopes and are associated with basalt. These soils have a dark grayish brown very gravelly loam or very stony sandy loam surface layer and a brown extremely gravelly loam or very cobbly sandy loam subsoil.

Of minor extent in this unit are Clinefalls and Era soils, Fluvents, Redcliff and Redslide soils, and Rock outcrop.

This unit is used as wildlife habitat and for livestock grazing.

The main limitations of this unit are slope and aspect. In areas that have slopes of more than 30 percent, range seeding with ground equipment is impractical and livestock distribution is restricted. The south-facing slopes are less suited to grazing during hot periods in summer. The shallow depth and rock fragments in the soils reduce available soil moisture.

Warm Soils on Lava Plains and Hills

This group consists of six map units. It makes up about 31 percent of the survey area.

5. Deschutes-Stukel-Rock outcrop

Moderately deep and shallow, well drained, sandy loam that formed in volcanic ash; on lava plains

This map unit is on lava plains in the area north of Bend to Juniper Butte. Elevation ranges from 2,500 to 4,000 feet. Slopes range from 0 to 30 percent. The mean annual precipitation is 8 to 12 inches, the mean annual air temperature is 47 to 52 degrees F, and the frost free period is 70 to 100 days.

This unit makes up about 8 percent of the survey area. It is about 30 percent Deschutes soils, 30 percent Stukel soils, and 15 percent Rock outcrop. The rest is soils of minor extent.

Deschutes soils are 20 to 40 inches deep to bedrock and are well drained. They are in depressions among numerous lava blisters on lava plains. These soils have a grayish brown sandy loam surface layer and a light grayish brown sandy loam subsoil.

Stukel soils are 10 to 20 inches deep to bedrock and are well drained. They are along the margins of depressions and on lava blisters. These soils have a grayish brown sandy loam and brown cobbly sandy loam surface layer and a pale brown gravelly sandy loam subsoil.

Of minor extent in this unit are Houstake, Lickskillet, Redcliff, Redmond, Redslide, Searles, Statz, and Tetherow soils.

This unit is used for irrigated cropland and livestock grazing.

Most of this unit is on young lava flows that are characterized by lava blisters, depressions, and rock outcroppings, which restrict irrigation systems and farming operations. There are significant areas that are not restricted by Rock outcrop and can be managed effectively. The sandy loam surface layer is susceptible to wind erosion and should not be left unprotected. The low available water capacity and moderately rapid permeability should be considered in irrigation water management. To minimize runoff and erosion, sprinkler irrigation should be used in areas that have slopes of more than 3 percent. The soils in this unit are very sensitive to overgrazing, and recovery rates can be slow. Pond development is limited by the depth to bedrock and risk of seepage.

6. Gosney-Deskamp-Rock outcrop

Moderately deep and shallow, somewhat excessively drained, stony loamy sand and loamy sand that formed in ash; on lava plains

This map unit is on lava plains east of Bend. It includes areas near Alfalfa that are underlain by alluvium and are used as irrigated cropland. Elevation ranges from 2,500 to 4,000 feet. Slopes range from 0 to 15 percent. The mean annual precipitation is 8 to 12 inches, the mean annual air temperature is 47 to 52 degrees F, and the frost-free period is 70 to 100 days.

This unit makes up about 8 percent of the survey area. It is about 40 percent Gosney soils, 35 percent

Deskamp soils, and 15 percent Rock outcrop. The rest is soils of minor extent.

Gosney soils are 10 to 20 inches deep to bedrock and are somewhat excessively drained. They are along the margins of depressions. These soils have a grayish brown stony loamy sand surface layer and a grayish brown loamy sand subsoil.

Deskamp soils are 20 to 40 inches deep to bedrock and are somewhat excessively drained. They are in depressions among numerous lava blisters. These soils have a brown loamy sand surface layer and a pale brown gravelly loamy sand subsoil.

Of minor extent in this unit are Clovkamp soils.

This unit is used for livestock grazing and irrigated cropland.

The main limitations of this unit are the loamy sand texture and the depth to bedrock. The soils in this unit are subject to wind erosion if they are left unprotected when applying range improvement practices. They are very sensitive to overgrazing, and recovery rates can be slow. Pond development is limited by the rapid permeability, depth to bedrock, and risk of seepage. Productivity is low because of the shallow depth of the Gosney soils and the very low available water capacity; therefore, careful management and range seeding with drought-tolerant species are needed. Most of this unit is on young lava flows that are characterized by lava blisters, depressions, and rock outcroppings, which restrict irrigation systems and farming operations. The very rapid intake rate, very low available water capacity, and rapid permeability should be considered in irrigation water management.

7. Madras-Agency-Cullius

Moderately deep and shallow, well drained soils that formed in loess over volcaniclastic material of the Deschutes Formation; on lava plains and hills

This map unit is on nearly level to sloping lava plains and hills in Jefferson County. Elevation ranges from 2,000 to 3,200 feet. Slopes range from 0 to 15 percent. The mean annual precipitation is 8 to 12 inches, the mean annual air temperature is 47 to 52 degrees F, and the frost-free period is 100 to 140 days.

This unit makes up about 8 percent of the survey area. It is about 50 percent Madras soils, 25 percent Agency soils, and 15 percent Cullius soils. The rest is soils of minor extent.

Madras soils are 22 to 40 inches deep to bedrock and are well drained. These soils have a brown sandy loam or loam surface layer and a yellowish brown clay loam subsoil.

Agency soils are 22 to 40 inches deep to bedrock and are well drained. These soils have a grayish brown sandy loam or loam surface layer and a pale brown loam subsoil.

Cullius soils are 10 to 20 inches deep to bedrock and are well drained. These soils have a grayish brown loam surface layer and a grayish brown clay and clay loam subsoil.

Of minor extent in this unit are Bakeoven, Era, Iris, Lickskillet, and Redcliff soils.

This unit is used mainly as irrigated cropland and pasture and for livestock grazing (fig. 1).

Figure 1.—Winter wheat on Madras and Agency soils in an area of general soil map unit 7. The shallow and steeper areas are used for livestock grazing. Mt. Jefferson is in background.

This unit is limited mainly by slope and the hazard of wind erosion. To minimize runoff and erosion, sprinkler irrigation should be used in areas that have slopes of more than 3 percent. In areas that have a sandy loam surface layer, wind erosion is a concern if the soils are left unprotected. Pond development is limited by the depth to bedrock.

8. Holmzie-Searles

Moderately deep, well drained soils that formed in volcanic ash over residuum; on hills

This map unit is on nearly level to sloping hills east of Sisters. Elevation ranges from 2,500 to 4,000 feet. Slopes range from 0 to 30 percent. The mean annual precipitation is 9 to 12 inches, the mean annual air temperature is 47 to 52 degrees F, and the frost-free period is 70 to 90 days.

This unit makes up about 2 percent of the survey area. It is about 40 percent Holmzie soils and 30 percent Searles soils. The rest is soils of minor extent.

Holmzie soils are 20 to 40 inches deep to bedrock and are well drained. They have a dark grayish brown loam surface layer and a reddish brown gravelly clay subsoil.

Searles soils are 20 to 40 inches deep to bedrock and are well drained. They have a grayish brown sandy loam surface layer and yellowish brown very gravelly clay loam subsoil.

Of minor extent in this unit are Buckbert, Lafollette, Redcliff, Redslide, Lickskillet, Deschutes, and Statz soils.

This unit is used mainly for livestock grazing, but the Lower Bridge area west of Terrebonne is used as irrigated cropland.

The main limitation of this unit for range management is the influence of surface ash. The soils are subject to wind erosion if they are left unprotected when applying range improvement practices. The soils are very sensitive to overgrazing, and recovery rates can be slow. Pond development is limited by the depth to bedrock.

9. Caphealy-Reuter

Moderately deep and shallow, well drained soils that formed in colluvium over volcaniclastic material of the Deschutes Formation; on hills

This map unit is on rolling hills east of Madras. Elevation ranges from 2,000 to 3,200 feet. Slopes range from 0 to 30 percent. The mean annual precipitation is 8 to 11 inches, the mean annual air temperature is 47 to 52 degrees F, and the frost-free period is 110 to 140 days.

The unit makes up about 2 percent of the survey area. It is about 45 percent Caphealy soils and 45 percent Reuter soils. The rest is soils of minor extent.

Caphealy soils are 20 to 40 inches deep to bedrock and are well drained. These soils have a brown sandy loam surface layer and a brown coarse sandy loam and gravelly coarse sand subsoil.

Reuter soils are 10 to 20 inches deep to bedrock and are well drained. These soils have a grayish brown sandy loam surface layer and a brown sandy loam subsoil.

Of minor extent in this unit are Era, Lickskillet, and Redcliff soils.

This unit is used for livestock grazing and irrigated cropland.

The main limitations of this unit are slope, the very low available water capacity, and the hazard of wind erosion. Because of the sandy loam texture of the surface layer, wind erosion is a concern if the soils are left unprotected. The soils are very sensitive to overgrazing, and recovery rates can be slow. Pond development is limited by the depth to bedrock. The very low available water capacity and the shallow depth of the Reuter soil limit the choice of species for range seeding to those that are drought-tolerant. The very low available water capacity and moderately rapid permeability should be considered in irrigation water management. To minimize runoff and erosion, sprinkler irrigation should be used in areas that have slopes of more than 3 percent.

10. Lickskillet-Redcliff-Schrier

Shallow, moderately deep, and very deep, well drained soils that formed in colluvium; on hills

This map unit is on rolling to steep hills north and east of Smith Rock. Elevation ranges from 2,600 to 4,500 feet. Slopes range from 0 to 60 percent. The mean annual precipitation is 10 to 14 inches, the mean annual air temperature is 47 to 52 degrees F, and the frost-free period is 70 to 140 days.

This unit makes up about 3 percent of the survey area. It is about 35 percent Lickskillet soils, 30 percent Redcliff soils, and 20 percent Schrier soils. The rest is soils of minor extent.

Lickskillet soils are 12 to 20 inches deep to bedrock and are well drained. They are on south-facing slopes. These soils have a dark grayish brown very gravelly loam surface layer and a brown extremely gravelly loam subsoil.

Redcliff soils are 20 to 40 inches deep to bedrock and are well drained. They are on south-facing slopes. These soils have a brown very gravelly loam surface layer and a dark yellowish brown extremely gravelly clay loam subsoil.

Schrier soils are more than 60 inches deep to bedrock and are well drained. They are on north-facing slopes. These soils have a very dark grayish brown silt loam surface layer, a dark brown silt loam and very gravelly silt loam subsoil, and a dark brown extremely gravelly fine sand substratum.

Of minor extent in this unit are Era, Haystack, and Simas on south-facing slopes and Tub soils on north-facing slopes.

This unit is used for livestock grazing.

Most of this unit is in the Crooked River National Grasslands. The main limitations are slope and aspect. In areas that have slopes of more than 30 percent, range seeding with ground equipment is impractical and livestock distribution is restricted. The south-facing slopes are less suited to grazing during hot periods in summer. The north-facing slopes have more effective soil moisture in summer for plant growth.

Cool Soils On Lava Plains and Hills

This group consists of four map units. It makes up about 32 percent of the survey area.

11. Dester-Gardone-Borobey

Moderately deep and very deep, excessively drained to well drained soils that formed in ash; in basins on lava plains

This map unit is on lava plains southeast of Bend, from Horse Ridge to Hampton. Elevation ranges from 4,000 to 4,800 feet. Slopes range from 0 to 20 percent. The mean annual precipitation is 10 to 12 inches, the mean annual air temperature is 43 to 45 degrees F, and the frost free period is 50 to 90 days.

This unit makes up about 11 percent of the survey area. It is about 40 percent Dester soils, 20 percent Gardone soils, and 15 percent Borobey soils. The rest is soils of minor extent.

Dester soils are 20 to 40 inches deep to bedrock and are well drained. They have slopes of 0 to 8 percent. These soils have a grayish brown sandy loam surface layer and a brown clay loam and gravelly clay loam subsoil.

Gardone soils are more than 60 inches deep to bedrock and are excessively drained. They have slopes of 0 to 20 percent. These soils have a dark grayish brown sand surface layer and a light brownish gray loamy sand substratum.

Borobey soils are more than 60 inches deep to bedrock and are somewhat excessively drained. They have slopes of 0 to 5 percent. These soils have a brown sandy loam surface layer and a pale brown sandy loam subsoil. Below this is a pale brown clay loam buried layer.

Of minor extent in this unit are Blayden, Milcan, Ninemile, Stookmoor, Swaler, and Swalesilver soils.

This unit is used for livestock grazing.

The main limitations of this unit are the cool temperatures and the sandy loam to sand texture of the surface layer. The cool soil temperature in spring delays plant growth. Wind erosion is a concern if the soils are left unprotected when applying range improvement practices. The soils are very sensitive to overgrazing, and natural revegetation can be slow. Pond development is limited by the risk of seepage.

12. Beden-Ninemile

Shallow, well drained soils that formed in residuum with ash on the surface; on lava plains

This map unit is on lava plains southeast of Bend, from Horse Ridge to Hampton. Elevation ranges from 4,100 to 5,500 feet. Slopes range from 0 to 10 percent. The mean annual precipitation is 9 to 14 inches, the mean annual air temperature is 43 to 45 degrees F, and the frost-free period is 50 to 90 days.

This unit makes up about 9 percent of the survey area. It is about 55 percent Beden soils and 25 percent Ninemile soils. The rest is soils of minor extent.

Beden soils are 10 to 20 inches deep to bedrock and are well drained. They have a grayish brown stony sandy loam surface layer and a brown loam and clay loam subsoil.

Ninemile soils are 10 to 20 inches deep to bedrock and are well drained. They have a grayish brown sandy loam surface layer and a pale brown clay and gravelly clay subsoil.

Of minor extent in this unit are Embal, Reluctan, Swaler, Swalesilver, and Vergas soils, Xerolls, and Rock outcrop.

This unit is used for livestock grazing.

The main limitations of this unit are the shallow soil depth and cool temperatures. The shallow soil depth and low precipitation limit productivity. The cool soil temperature in spring delays plant growth. The shallow depth to bedrock limits pond development. Wind erosion can be a concern if the soils are left unprotected when applying range improvement practices.

13. Stookmoor-Menbo

Moderately deep, somewhat excessively drained and well drained soils that formed in ash and colluvium; on hills

This map unit is on hills southeast of Bend, from Horse Ridge to Hampton. Elevation ranges from 4,300 to 5,500 feet. Slopes range from 1 to 50 percent. The mean annual precipitation is 10 to 14 inches, the mean annual air temperature is 43 to 45 degrees F, and the frost-free period is 50 to 90 days.

This unit makes up about 5 percent of the survey area. It is about 40 percent Stookmoor soils and 30 percent Menbo soils. The rest is soils of minor extent.

Stookmoor soils are 20 to 40 inches deep to bedrock and are somewhat excessively drained. They have a grayish brown loamy sand surface layer and a pale brown sandy loam subsoil.

Menbo soils are 20 to 40 inches deep to bedrock and are well drained. They have a grayish brown stony loam surface layer and a brown very cobbly clay loam subsoil.

Of minor extent in this unit are Beden, Choptie, Ninemile, Redcliff, Reluctan, and Westbutte soils and Rock outcrop.

This unit is used for livestock grazing.

The main limitations are steepness of slope and the cool temperatures. The low precipitation limits productivity. The cool soil temperature in spring delays plant growth. The restricted soil depth and the slope limit pond development. Wind erosion can be a concern if the Stookmoor soils are left unprotected when applying range improvement practices.

14. Wanoga-Fremkle-Rock outcrop

Moderately deep and shallow, well drained soils that formed in ash; on hills

This map unit is on nearly level to steep hills west of Bend and north of Sisters. It is a transition zone from the dry range plant communities to the more moist forested plant communities. Elevation ranges from 2,800 to 4,000 feet. Slopes range from 0 to 50 percent, but most are less than 15 percent. The mean annual precipitation is 12 to 18 inches, the mean annual air temperature is 42 to 47 degrees F, and the frost-free period is 60 to 90 days.

This unit makes up about 7 percent of the survey area. It is about 35 percent Wanoga soils, 25 percent Fremkle soils, and 20 percent Rock outcrop. The rest is soils of minor extent.

Wanoga soils are 20 to 40 inches deep to bedrock and are well drained. They have a dark brown sandy loam surface layer and a dark brown sandy loam subsoil.

Fremkle soils are 10 to 20 inches deep to bedrock and are well drained. They have a dark brown sandy loam surface layer and a dark brown sandy loam subsoil.

Of minor extent in this unit are Bluesters, Fryrear, Henkle, Laidlaw, Omahaling, and Wilt soils.

This unit is used mainly for livestock grazing and timber production.

The main limitations of this unit are the soil depth and cool temperatures. The shallow depth of the Fremkle soil and the areas of Rock outcrop limit productivity. Seeding with ground equipment is impractical in most areas because of the steepness of slope and the areas of Rock outcrop. The cool soil temperature in spring delays plant growth. The restricted soil depth and risk of seepage limit pond development. Wind erosion can be a concern if the soils are left unprotected when applying range improvement practices. Survival of ponderosa pine seedlings is limited because of the low precipitation. Windthrow is a hazard because of the shallow rooting depth and areas of Rock outcrop. The thin organic layer and sandy loam surface layer are susceptible to compaction, displacement, and erosion in the steeper areas.

Soils on Glacial Moraines and Outwash Plains

This group consists of three map units. It makes up about 6 percent of the survey area.

15. Linksterly-Belrick-Douthit

Very deep, well drained, cold soils that formed in ash over glacial till; on glacial moraines

This map unit is on glacial moraines on the foot slopes of the Cascade Mountains, north of Sisters. Elevation ranges from 3,700 to 5,200 feet. Slopes range from 0 to 50 percent. The mean annual precipitation is 50 to 70 inches, the mean annual air temperature is 35 to 44 degrees F, and the frost-free period is 10 to 50 days.

This unit makes up about 3 percent of the survey area. It is about 35 percent Linksterly soils, 25 percent Belrick soils, and 20 percent Douthit soils. The rest is soils of minor extent.

Linksterly soils are more than 60 inches deep to bedrock and are well drained. They have a very dark grayish brown sandy loam surface layer and a substratum that is black and very dark brown loamy fine sand in the upper part and dark reddish brown very cobbly sandy loam in the lower part.

Belrick soils are more than 60 inches deep to bedrock and are well drained. These soils are on north-facing slopes. They have a very dark brown fine sandy loam surface layer and a dark yellowish brown extremely stony sandy loam subsoil.

Douthit soils are more than 60 inches deep to bedrock and are well drained. These soils are on south-facing slopes. They have a very dark grayish brown sandy loam surface layer and a dark brown extremely stony sandy loam subsoil.

Of minor extent in this unit are Bott, Haynap, Kweo, and Minkwell soils.

This unit is used mainly for timber production and wildlife habitat.

The main limitations of this unit are the cold temperatures, slope, and the sandy loam texture of the surface layer. The thin organic layer and sandy loam surface layer are susceptible to compaction, displacement, and erosion in the steeper areas. At elevations of more than about 4,400 feet, severe frost heaving or frost can damage or kill conifer seedlings.

16. Lundgren-Allingham-Circle

Cool soils that are moderately deep and deep to glacial outwash, are well drained, and formed in ash over glacial outwash; on outwash plains

This map unit is on outwash plains in and around Sisters and in the Metolius Basin. Elevation ranges from 2,500 to 4,000 feet. Slopes range from 0 to 30 percent, but most are less than 15 percent. The mean annual precipitation is 12 to 35 inches, the mean annual air temperature is 40 to 47 degrees F, and the frost-free period is 50 to 90 days.

This unit makes up about 2 percent of the survey area. It is about 40 percent Lundgren soils, 15 percent Allingham soils, and 15 percent Circle soils. The rest is soils of minor extent.

Lundgren soils are 20 to 40 inches deep to glacial outwash and are well drained. Slopes are 0 to 3 percent. They have a very dark grayish brown sandy loam surface layer, a brown gravelly sandy loam subsoil, and a dark brown and brown very gravelly loam and extremely gravelly sandy loam substratum.

Allingham soils are 20 to 40 inches deep to glacial outwash and are well drained. Slopes are 0 to 30 percent. They have a dark brown gravelly sandy loam surface layer and a dark brown and dark yellowish brown loam, very gravelly clay loam, and very cobbly clay loam subsoil.

Circle soils are 40 to 60 inches deep to glacial outwash and are well drained. Slopes are 0 to 30 percent. They have a dark brown sandy loam surface layer and a dark brown and dark yellowish brown loam, gravelly loam, and very gravelly clay loam subsoil.

Of minor extent in this unit are Cryaquolls, and Ermabell, Omahaling, Suilotem, Suttle, and Wizard soils.

This unit is used mainly for timber production and wildlife habitat.

The main limitation of this unit is the sandy loam texture of the surface layer. The thin organic layer and sandy loam surface layer are susceptible to compaction, displacement, and erosion in the steeper areas.

17. Tumalo-Plainview

Warm soils that are moderately deep to a duripan or to glacial outwash, are well drained, and formed in ash over glacial outwash; on outwash plains

This map unit is on outwash plains east of Sisters. Elevation ranges from 3,000 to 4,000 feet. Slopes range from 0 to 8 percent. The mean annual precipitation is 10 to 12 inches, the mean annual air temperature is 47 to 52 degrees F, and the frost-free period is 70 to 100 days.

This unit makes up about 1 percent of the survey area. It is about 50 percent Tumalo soils and 40 percent Plainview soils. The rest is soils of minor extent.

Tumalo soils are 20 to 40 inches deep to a duripan and are well drained. They have a grayish brown sandy loam surface layer and a pale brown very gravelly sandy loam subsoil. Below this is a very pale brown duripan over glacial outwash.

Plainview soils are 20 to 40 inches deep to glacial outwash and more than 60 inches deep to bedrock and are well drained. They have a dark grayish brown sandy loam surface layer, a pale brown and light brownish gray very gravelly sandy loam subsoil, and a pale brown and light brownish gray extremely gravelly sandy loam and very gravelly loamy sand substratum. A duripan is at a depth of 50 to 65 inches.

Of minor extent in this unit are Deschutes and Stukel soils.

This unit is used for irrigated cropland and livestock grazing.

The main limitations of this unit are the sandy loam texture of the surface layer and the risk of seepage. The sandy loam surface layer is susceptible to wind erosion if it is left unprotected. To reduce runoff and erosion, sprinkler irrigation should be used in areas that have slopes of more than 3 percent. These soils are very sensitive to overgrazing, and recovery rates can be slow. Pond development is limited by the risk of seepage.

Soils on Mountains

This group consists of three map units. It makes up about 9 percent of the survey area.

18. Sisters-Yapoah

Very deep, well drained and somewhat excessively drained, cool soils that formed in colluvium that is high *in content of ash or in ash over colluvium and residuum*

This map unit is on nearly level to very steep uplands. Elevation ranges from 3,200 to 5,000 feet. Slopes range from 0 to 75 percent. The mean annual precipitation is 18 to 30 inches, the mean annual air temperature is 40 to 47 degrees F, and the frost-free period is 50 to 90 days.

This unit makes up about 1 percent of the survey area. It is about 50 percent Sisters soils and 35 percent Yapoah soils. The rest is soils of minor extent.

Sisters soils are more than 60 inches deep to bedrock and are well drained. They have a dark brown loamy sand surface layer and a dark reddish brown clay loam and loam subsoil.

Yapoah soils are more than 60 inches deep to bedrock and are somewhat excessively drained. They have a dark brown very cobbly loamy sand surface layer and a dark yellowish brown extremely flaggy loamy sand subsoil.

Of minor extent in this unit are Shroyton soils.

This unit is used mainly for timber production and wildlife habitat.

The main limitations of this unit are slope and the loamy sand texture of the surface layer. The thin organic layer and the sandy surface layer are susceptible to compaction, displacement, and erosion in the steeper areas.

19. Smiling-Windego-Parrego

Very deep and moderately deep, well drained, cool soils that formed in ash over colluvium and residuum

This map unit is on the eastern slopes and western scarp of Green Ridge. Elevation ranges from 2,500 to 4,000 feet. Slopes range from 0 to 70 percent. The mean annual precipitation is 15 to 50 inches, the mean annual air temperature is 40 to 47 degrees F, and the frost-free period is 50 to 90 days.

This unit makes up about 6 percent of the survey area. It is about 40 percent Smiling soils, 25 percent Windego soils, and 25 percent Parrego soils. The rest is soils of minor extent.

Smiling soils are more than 60 inches deep to bedrock and are well drained. They have a dark brown sandy loam surface layer and a dark brown loam and clay loam subsoil.

Windego soils are more than 60 inches deep to bedrock and are well drained. They have a dark brown sandy loam surface layer and a dark brown very cobbly clay loam subsoil.

Parrego soils are 20 to 40 inches deep to soft bedrock and are well drained. They have a dark brown sandy loam surface layer and a brown clay loam subsoil.

Of minor extent in this unit are Flarm and Thorn soils.

This unit is used mainly for timber production and wildlife habitat.

The main limitations of this unit are slope and the sandy loam texture of the surface layer. The thin organic layer and sandy loam surface layer are susceptible to compaction, displacement, and erosion in the steeper areas.

20. Gap-Prairie

Deep and moderately deep, well drained, cold soils that formed in ash over colluvium and residuum

This map unit is on the higher eastern slopes of Green Ridge. Elevation ranges from 4,000 to 5,000 feet. Slopes range from 0 to 50 percent. The mean annual precipitation is 25 to 35 inches, the mean annual air temperature is 40 to 44 degrees F, and the frost-free period is 10 to 50 days.

This unit makes up about 2 percent of the survey area. It is about 50 percent Gap soils and 35 percent Prairie soils. The rest is soils of minor extent.

Gap soils are 40 to 60 inches deep to soft bedrock and are well drained. They have a reddish brown sandy loam surface layer and a dark brown gravelly and cobbly loam subsoil.

Prairie soils are 20 to 40 inches deep to soft bedrock and are well drained. They have a dark brown sandy loam surface layer and a dark brown gravelly and cobbly loam subsoil.

Of minor extent in this unit are Bott, Glaze, and Kweo soils.

This unit is used mainly for timber production and wildlife habitat.

The main limitations of this unit are slope, the sandy loam texture of the surface layer, and the cold temperatures. Severe frost heaving or frost can kill or damage conifer seedlings. The thin organic layer and sandy loam surface layer are susceptible to compaction, displacement, and erosion in the steeper areas.

Detailed Soil Map Units

The map units delineated on the detailed maps at the back of this survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions in this section, along with the maps, can be used to determine the suitability and potential of a unit for specific uses. They also can be used to plan the management needed for those uses. More information about each map unit is given under the heading "Use and Management of the Soils."

A map unit delineation on a map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils or miscellaneous areas. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils and miscellaneous areas are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some "included" areas that belong to other taxonomic classes.

Most included soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, inclusions. They may or may not be mentioned in the map unit description. Other included soils and miscellaneous areas, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, inclusions. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. The included areas of contrasting soils or miscellaneous areas are mentioned in the map unit descriptions. A few included areas may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of inclusions in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans, but if intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives the principal hazards and limitations to be considered in planning for specific uses.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Agency sandy loam, 0 to 3 percent slopes, is a phase of the Agency series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Allingham-Circle complex, 0 to 15 percent slopes, is an example.

This survey includes *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Lava flows is an example.

Table 4 gives the acreage and proportionate extent of each map unit. Other tables give properties of the soils and the limitations, capabilities, and potentials for many uses. The Glossary defines many of the terms used in describing the soils or miscellaneous areas.

In the map unit descriptions that follow, a semitabular format is used. In this format a boldface heading (for example, **Composition**) is used to identify the kind of information grouped directly below it. Introducing each item of information under the heading is an italicized term or phrase (for example, *Landscape position:*) that identifies or describes the information. Many of the boldface headings and introductory terms or phrases are self-explanatory; however, some of them need further explanation. These explanations are provided in the following paragraphs, generally in the order in which they are used in the map unit descriptions.

Composition is given for the components identified in the name of the map unit as well as for the contrasting inclusions.

Inclusions are areas of components (soils or miscellaneous areas) that differ from the components for which the unit is named. Inclusions can be either similar or contrasting. *Similar inclusions* are components that differ from the components for which the unit is named but that for purposes of use and management can be considered to be the same as the named components. Note that in the “Composition” paragraph a single percentage is provided for a named soil and the similar inclusions because their use and management are similar.

Contrasting inclusions are components that differ sufficiently from the components for which the unit is named that they would have different use and management if they were extensive enough to be managed separately. For most uses, contrasting inclusions have limited effect on use and management. Inclusions generally are in small areas, and they could not be mapped separately because of the scale used. Some small areas of strongly contrasting inclusions are identified by a special symbol on the detailed soil maps. A few inclusions may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the inclusions on the landscape.

Landscape position refers to the dominant position or positions on the landform or landforms on which the component is located. In naming landscape positions, an effort has been made to give the specific position of the component rather than a general position that could encompass other components. For some landforms, distinctive landscape positions cannot be described and thus are not given.

Landform refers to the dominant three-dimensional part or parts of the land surface on which the component is located. In naming landforms, an effort has been made to name the specific landform on which the component occurs. In some instances, however, the component may occur on more than one landform.

Typical profile is a vertical, two-dimensional section of the soil extending from the surface to a restrictive layer or to a depth of 60 inches or more.

Permeability is the quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of inches per hour that water moves downward through the saturated soil.

Available water capacity is the capacity of the soil to hold water available for use by most plants. It commonly is expressed as inches of water per inch of soil (see “Glossary”).

Major uses are the dominant uses at the time the major part of the fieldwork for this survey was completed.

Major management limitations are those factors that affect the use of the soils for the major uses. The major management limitations may apply to the entire unit or to a given component of the unit.

General management considerations provide additional perspective on the suitability and limitations of the unit for the major uses. They may apply to the entire unit or to a given component of the unit.

1A—Agency sandy loam, 0 to 3 percent slopes

Composition

Agency soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Loess over semiconsolidated sediment
Elevation: 2,000 to 3,200 feet
Native plants: Western juniper, basin big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
Mean annual precipitation—8 to 10 inches

Mean annual air temperature—47 to 50 degrees F
Frost-free period—120 to 140 days

Typical Profile

0 to 8 inches—grayish brown sandy loam
8 to 24 inches—brown loam
24 to 29 inches—pale brown cobbly loam
29 to 33 inches—weathered tuff
33 inches—welded tuff of the Deschutes Formation

Soil Properties and Qualities

Depth: Bedrock at a depth of 22 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 4 inches

Contrasting Inclusions

- Era soils in swales
- Cullius soils on lava plains
- Caphealy and Reuter soils on adjacent hills
- Soils that have stones on the surface

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Surface texture, soil depth, permeability, climate

General Management Considerations

Irrigated cropland

- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and risk of seepage.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Droughty Loam 8-10pz

2A—Agency loam, 0 to 3 percent slopes

Composition

Agency soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Loess over semiconsolidated sediment
Elevation: 2,000 to 3,200 feet
Native plants: Western juniper, basin big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
Mean annual precipitation—8 to 10 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—120 to 140 days

Typical Profile

0 to 8 inches—grayish brown loam
8 to 24 inches—brown loam
24 to 29 inches—pale brown cobbly loam
29 to 33 inches—weathered tuff
33 inches—welded tuff of the Deschutes Formation

Soil Properties and Qualities

Depth: Bedrock at a depth of 22 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 4 inches

Contrasting Inclusions

- Era soils in swales
- Cullius soils on lava plains
- Caphealy and Reuter soils on adjacent hills
- Soils that have stones on the surface
- Soils that have a silt loam surface layer

Major Uses

Irrigated cropland (fig. 2), livestock grazing

Figure 2.—Onions in an area of Agency loam, 0 to 3 percent slopes. Mt. Jefferson in the Cascade Range in background.

Major Management Limitations

Soil depth, permeability, climate

General Management Considerations

Irrigated cropland

- This soil is well suited to irrigated crops.

Livestock grazing

- Pond development is limited by the soil depth and risk of seepage.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Droughty Loam 8-10pz

2B—Agency loam, 3 to 8 percent slopes

Composition

Agency soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Loess over semiconsolidated sediment
Elevation: 2,000 to 3,200 feet
Native plants: Western juniper, basin big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
  Mean annual precipitation—8 to 10 inches
  Mean annual air temperature—47 to 50 degrees F
  Frost-free period—120 to 140 days

Typical Profile

0 to 8 inches—grayish brown loam
8 to 24 inches—brown loam
24 to 29 inches—pale brown cobbly loam
29 to 33 inches—weathered tuff
33 inches—welded tuff of the Deschutes Formation

Soil Properties and Qualities

Depth: Bedrock at a depth of 22 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 4 inches

Contrasting Inclusions

- Era soils in swales
- Caphealy and Reuter soils on adjacent hills
- Soils that have stones on the surface
- Soils that have a silt loam surface layer

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Slope, soil depth, permeability, climate

General Management Considerations

Irrigated cropland

- Because of the steepness of slope, sprinkler irrigation systems should be used to reduce runoff and erosion.

Livestock grazing

- Pond development is limited by the soil depth and risk of seepage.

- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Droughty Loam 8-10pz

2C—Agency loam, 8 to 15 percent slopes

Composition

Agency soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Loess over semiconsolidated sediment
Elevation: 2,000 to 3,200 feet
Native plants: Western juniper, basin big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
  Mean annual precipitation—8 to 10 inches
  Mean annual air temperature—47 to 50 degrees F
  Frost-free period—120 to 140 days

Typical Profile

0 to 8 inches—grayish brown loam
8 to 24 inches—brown loam
24 to 29 inches—pale brown cobbly loam
29 to 33 inches—weathered tuff
33 inches—welded tuff of the Deschutes Formation

Soil Properties and Qualities

Depth: Bedrock at a depth of 22 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 4 inches

Contrasting Inclusions

- Era soils in swales
- Caphealy and Reuter soils on adjacent hills
- Soils that have stones on the surface
- Soils that have a silt loam surface layer

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Slope, soil depth, permeability, climate

General Management Considerations

Irrigated cropland

- Because of the steepness of slope, sprinkler irrigation systems should be used to reduce runoff and erosion.

Livestock grazing

- Pond development is limited by the soil depth, steepness of slope, and risk of seepage.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Droughty Loam 8-10pz

3B—Agency-Madras complex, 0 to 8 percent slopes

Composition

Agency soil and similar inclusions—45 percent
Madras soil and similar inclusions—40 percent
Contrasting inclusions—15 percent

Setting

Landform: Hills
Parent material: Loess over semiconsolidated sediment
Elevation: 2,700 to 3,200 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
  Mean annual precipitation—10 to 12 inches
  Mean annual air temperature—49 to 52 degrees F
  Frost-free period—110 to 130 days

Typical Profile of the Agency Soil

0 to 8 inches—grayish brown loam
8 to 24 inches—brown loam
24 to 29 inches—pale brown cobbly loam
29 to 33 inches—weathered tuff
33 inches—welded tuff of the Deschutes Formation

Properties and Qualities of the Agency Soil

Depth: Bedrock at a depth of 22 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 4 inches

Typical Profile of the Madras Soil

0 to 10 inches—brown loam
10 to 23 inches—yellowish brown loam and clay loam
23 to 27 inches—semiconsolidated sediment consisting of gravel, cobbles, and sand of the Deschutes Formation
27 inches—basalt of the Deschutes Formation

Properties and Qualities of the Madras Soil

Depth: Bedrock at a depth of 22 to 40 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 4 inches

Contrasting Inclusions

- Bakeoven soils in intermound areas
- Deep, silty soils on mounds

Major Use

Livestock grazing

Major Management Limitations

Soil depth, permeability

General Management Considerations

- Pond development is limited by the soil depth and risk of seepage.

Range Site

Loamy 10-12pz

3C—Agency-Madras complex, 8 to 15 percent slopes

Composition

Agency soil and similar inclusions—45 percent
Madras soil and similar inclusions—40 percent
Contrasting inclusions—15 percent

Setting

Landform: Hills
Parent material: Loess over semiconsolidated sediment
Elevation: 2,700 to 3,200 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—49 to 52 degrees F
Frost-free period—110 to 130 days

Typical Profile of the Agency Soil

0 to 8 inches—grayish brown loam
8 to 24 inches—brown loam
24 to 29 inches—pale brown cobbly loam
29 to 33 inches—weathered tuff
33 inches—welded tuff of the Deschutes Formation

Properties and Qualities of the Agency Soil

Depth: Bedrock at a depth of 22 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 4 inches

Typical Profile of the Madras Soil

0 to 10 inches—brown loam
10 to 23 inches—yellowish brown loam and clay loam
23 to 27 inches—semiconsolidated sediment consisting of gravel, cobbles, and sand of the Deschutes Formation
27 inches—basalt of the Deschutes Formation

Properties and Qualities of the Madras Soil

Depth: Bedrock at a depth of 22 to 40 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 4 inches

Contrasting Inclusions

- Bakeoven soils in intermound areas
- Deep, silty soils on mounds

Major Use

Livestock grazing

Major Management Limitations

Soil depth, permeability, slope

General Management Considerations

- Pond development is limited by the soil depth, steepness of slope, and risk of seepage.

Range Site

Loamy 10-12pz

4C—Allingham-Circle complex, 0 to 15 percent slopes

Composition

Allingham soil and similar inclusions—50 percent
Circle soil and similar inclusions—50 percent

Setting

Landform: Outwash plains
Parent material: Ash over glacial outwash
Elevation: 2,500 to 3,500 feet
Native plants: Ponderosa pine, antelope bitterbrush, greenleaf manzanita, Idaho fescue
Climatic factors:
Mean annual precipitation—20 to 35 inches
Mean annual air temperature—40 to 47 degrees F
Frost-free period—50 to 90 days

Typical Profile of the Allingham Soil

1 inch to 0—organic mat
0 to 16 inches—very dark grayish brown and dark brown gravelly sandy loam
16 to 28 inches—dark brown loam
28 to 65 inches—dark yellowish brown very gravelly and very cobbly clay loam

Properties and Qualities of the Allingham Soil

Depth: Glacial outwash at a depth of 20 to 40 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 8 inches

Typical Profile of the Circle Soil

1 inch to 0—organic mat
0 to 16 inches—dark brown sandy loam
16 to 42 inches—dark brown and dark yellowish brown loam and gravelly loam
42 to 65 inches—dark yellowish brown very gravelly clay loam

Properties and Qualities of the Circle Soil

Depth: Glacial outwash at a depth of 40 to 50 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 9 inches

Major Use

Woodland

Major Management Limitations

Low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

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CP-S2-17

4D—Allingham-Circle complex, 15 to 30 percent slopes

Composition

Allingham soil and similar inclusions—50 percent
Circle soil and similar inclusions—50 percent

Setting

Landform: Outwash plains
Parent material: Ash over glacial outwash
Elevation: 2,500 to 3,500 feet
Native plants: Ponderosa pine, antelope bitterbrush, greenleaf manzanita, Idaho fescue
Climatic factors:
Mean annual precipitation—20 to 35 inches
Mean annual air temperature—40 to 47 degrees F
Frost-free period—50 to 90 days

Typical Profile of the Allingham Soil

1 inch to 0—organic mat
0 to 16 inches—very dark grayish brown and dark brown gravelly sandy loam
16 to 28 inches—dark brown loam
28 to 65 inches—dark yellowish brown very gravelly and very cobbly clay loam

Properties and Qualities of the Allingham Soil

Depth: Glacial outwash at a depth of 20 to 40 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 8 inches

Typical Profile of the Circle Soil

1 inch to 0—organic mat
0 to 16 inches—dark brown sandy loam
16 to 42 inches—dark brown and dark yellowish brown loam and gravelly loam
42 to 65 inches—dark yellowish brown very gravelly clay loam

Properties and Qualities of the Circle Soil

Depth: Glacial outwash at a depth of 40 to 60 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 9 inches

Major Use

Woodland

Major Management Limitations

Slope, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Wheeled and tracked equipment can be used; however, cable yarding generally is safer and disturbs the soil less.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

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5A—Aquolls, 0 to 1 percent slopes

Composition

Aquolls—95 percent
Contrasting inclusions—5 percent

Setting

Landform: Closed basins
Slope: 0 to 1 percent
Parent material: Lacustrine sediment
Elevation: 2,800 to 2,900 feet
Native plants: Quaking aspen, willow, sedges
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—70 to 90 days

Representative Profile

0 to 3 inches—black loam
3 to 11 inches—black silt loam
11 to 20 inches—very dark gray, mottled silt loam
20 to 60 inches—dark grayish brown, mottled silty clay

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Poorly drained
Depth to water table: 6 to 12 inches below the surface in April through June
Permeability: Slow
Available water capacity: About 12 inches

Contrasting Inclusions

- Deep, moderately well drained soils along the margins of basins

Major Use

Livestock grazing

Major Management Limitations

High water table, climate

General Management Considerations

- If seeding is needed, select plants that tolerate seasonal wetness.
- Grazing during wet periods can cause soil compaction and displacement and damage plants.
- The cold climate and soil temperature delay the growth of forage and shorten the growing season.

Range Site

Wet Meadow

6A—Bakeoven very cobbly loam, 0 to 3 percent slopes

Composition

Bakeoven soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Residuum
Elevation: 2,000 to 3,200 feet
Native plants: Stiff sagebrush, Sandberg bluegrass, bluebunch wheatgrass, bottlebrush squirreltail
Climatic factors:
Mean annual precipitation—9 to 11 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—110 to 140 days

Typical Profile

0 to 2 inches—brown very cobbly loam

2 to 6 inches—brown very gravelly loam
6 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 4 to 10 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 1 inch

Contrasting Inclusions

- Soils that are moderately deep to bedrock
- Areas of exposed bedrock

Major Use

Livestock grazing

Major Management Limitations

Soil depth, rock fragments in surface layer, available water capacity

General Management Considerations

- Pond development is limited by the soil depth.
- The low available water capacity and restricted soil depth limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface.

Range Site

Very Shallow Loam 10-14pz

7A—Bakeoven-Agency-Madras complex, 0 to 3 percent slopes

Composition

Bakeoven soil and similar inclusions—30 percent
Agency soil and similar inclusions—30 percent
Madras soil and similar inclusions—30 percent
Contrasting inclusions—10 percent

Setting

Landscape position: Bakeoven soil—intermounds; Agency and Madras soils—mounds
Landform: Lava plains
Parent material: Bakeoven soil—residuum; Agency and Madras soils—loess over semiconsolidated sediment
Elevation: 2,000 to 3,000 feet
Native plants: Bakeoven soil—stiff sagebrush, Sandberg bluegrass, bluebunch wheatgrass, bottlebrush squirreltail; Agency and Madras soils—western juniper, mountain big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—49 to 52 degrees F
Frost-free period—110 to 130 days

Typical Profile of the Bakeoven Soil

0 to 2 inches—brown very cobbly loam
2 to 6 inches—brown very gravelly loam
6 inches—basalt

Properties and Qualities of the Bakeoven Soil

Depth: Bedrock at a depth of 4 to 10 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 1 inch

Typical Profile of the Agency Soil

0 to 8 inches—grayish brown loam
8 to 24 inches—brown loam
24 to 29 inches—pale brown cobbly loam
29 to 33 inches—weathered tuff
33 inches—welded tuff of the Deschutes Formation

Properties and Qualities of the Agency Soil

Depth: Bedrock at a depth of 22 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 4 inches

Typical Profile of the Madras Soil

0 to 10 inches—brown loam
10 to 23 inches—yellowish brown loam and clay loam
23 to 27 inches—semiconsolidated sediment consisting of gravel, cobbles, and sand of the Deschutes Formation
27 inches—basalt of the Deschutes Formation

Properties and Qualities of the Madras Soil

Depth: Bedrock at a depth of 22 to 40 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 4 inches

Contrasting Inclusions

- Deep, silty soils on mounds

Major Use

Livestock grazing

Major Management Limitations

Bakeoven soil—soil depth, rock fragments in surface layer, available water capacity
Agency and Madras soils—soil depth

General Management Considerations

- Pond development is limited by the soil depth.
- The low available water capacity and restricted depth of the Bakeoven soil limit the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface of the Bakeoven soil.

Range Site

Bakeoven soil—Very Shallow Loam 10-14pz
Agency and Madras soils—Loamy 10-12pz

8B—Beden sandy loam, dry, 1 to 8 percent slopes

Composition

Beden soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash over residuum derived from basalt or welded tuff
Elevation: 4,100 to 4,800 feet
Native plants: Wyoming big sagebrush, bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—9 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 11 inches—grayish brown and brown sandy loam
11 to 15 inches—brown loam
15 to 18 inches—brown clay loam
18 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 3 inches

Contrasting Inclusions

- Reluctan and Ninemile soils on lava plains
- Embal soils in drainageways

Major Use

Livestock grazing

Major Management Limitations

Climate, soil depth, surface texture

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because this soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth.
- The low annual precipitation and restricted soil depth limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.

Range Site

Shallow Pumice 9-11pz

9C—Beden sandy loam, moist, 3 to 15 percent slopes

Composition

Beden soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash over residuum derived from basalt or welded tuff
Elevation: 4,100 to 4,800 feet
Native plants: Western juniper, mountain big sagebrush, Idaho fescue, Thurber needlegrass
Climatic factors:
Mean annual precipitation—9 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 11 inches—grayish brown and brown sandy loam
11 to 15 inches—brown loam
15 to 18 inches—brown clay loam
18 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 3 inches

Contrasting Inclusions

- Stookmoor soils on ridgetops
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Climate, surface texture, soil depth

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because this soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth.
- The low annual precipitation and restricted soil depth limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Shallow Pumice Hills 9-11pz

10E—Beden sandy loam, 30 to 50 percent north slopes

Composition

Beden soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landscape position: North-facing slopes
Landform: Hills
Parent material: Ash over residuum derived from basalt or welded tuff
Elevation: 4,200 to 5,000 feet
Native plants: Mountain big sagebrush, Idaho fescue, bluebunch wheatgrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 11 inches—grayish brown and brown sandy loam
11 to 15 inches—brown loam
15 to 18 inches—brown clay loam
18 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 3 inches

Contrasting Inclusions

- Ninemile soils on lava plains
- Westbutte soils on hillsides
- Rock outcrop on knolls

Major Use

Livestock grazing

Major Management Limitations

Climate, soil depth, surface texture, slope

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because this soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the steepness of slope and soil depth.
- The low annual precipitation and restricted soil depth limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.
- The steepness of slope restricts livestock distribution and makes range seeding with ground equipment impractical.

Range Site

North Slopes 10-12pz

11B—Beden stony sandy loam, 0 to 10 percent slopes

Composition

Beden soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash over residuum derived from basalt

or welded tuff
Elevation: 4,100 to 4,800 feet
Native plants: Western juniper, low sagebrush, Idaho fescue, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—9 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 11 inches—grayish brown and brown stony sandy loam
11 to 15 inches—brown loam
15 to 18 inches—brown clay loam
18 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 3 inches

Contrasting Inclusions

- Ninemile soils on lava plains
- Embal soils in drainageways

Major Use

Livestock grazing

Major Management Limitations

Climate, soil depth, surface texture, rock fragments in surface layer

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because this soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth.
- The low annual precipitation and restricted soil depth limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface.

Range Site

Juniper Lava Benches 9-12pz

12B—Beden-Ninemile complex, 0 to 10 percent slopes

Composition

Beden soil and similar inclusions—45 percent
Ninemile soil and similar inclusions—40 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash over residuum
Elevation: 4,200 to 4,800 feet
Native plants: Beden soil—western juniper, low sagebrush, Idaho fescue, Sandberg bluegrass; Ninemile soil—low sagebrush, Idaho fescue, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile of the Beden Soil

0 to 11 inches—grayish brown and brown stony sandy loam
11 to 15 inches—brown loam
15 to 18 inches—brown clay loam
18 inches—basalt

Properties and Qualities of the Beden Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 3 inches

Typical Profile of the Ninemile Soil

0 to 7 inches—grayish brown sandy loam
7 to 19 inches—pale brown clay and gravelly clay
19 inches—basalt

Properties and Qualities of the Ninemile Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Very slow
Available water capacity: About 3 inches

Contrasting Inclusions

- Very shallow soils that have a very stony surface layer and are along bedrock escarpments
- Embal and Dester soils in drainageways

- Choptie soils on hills
- Reluctan soils on lava plains

Major Use

Livestock grazing

Major Management Limitations

Climate, soil depth, surface texture, rock fragments in surface layer

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soils in this unit are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth.
- The low annual precipitation and restricted soil depth limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface.

Range Site

Beden soil—Juniper Lava Benches 9-12pz
Ninemile soil—Pumice Claypan 9-11pz

13C—Belrick fine sandy loam, 0 to 15 percent slopes

Composition

Belrick soil and similar inclusions—95 percent
Contrasting inclusions—5 percent

Setting

Landform: Moraines
Parent material: Ash over glacial till
Elevation: 3,700 to 4,400 feet
Native plants: Ponderosa pine, white fir, snowbrush, chinkapin, pinegrass
Climatic factors:
Mean annual precipitation—50 to 60 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—20 to 50 days

Typical Profile

1 inch to 0—organic mat
0 to 16 inches—very dark brown fine sandy loam
16 to 24 inches—very dark brown and black loamy fine sand and fine sand
24 to 65 inches—dark yellowish brown extremely stony sandy loam

Soil Properties and Qualities

Depth: Glacial till at a depth of 20 to 40 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 6 inches

Contrasting Inclusions

- Douthit soils on side slopes
- Soils that have glacial till at a depth of 40 inches or more
- Soils that flood in spring and are adjacent to creeks

Major Use

Woodland

Major Management Limitations

Low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical or chemical treatment or by livestock grazing.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the susceptibility to compaction, all ground operations, including tractor skidding, mechanical harvesting, and machine piling, should be avoided unless the surface layer is frozen or covered with snow. Subsoiling can be used to loosen the compacted layer.

Forest Service Plant Association

CW-C2-12

13D—Belrick fine sandy loam, 15 to 30 percent slopes

Composition

Belrick soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Moraines
Parent material: Ash over glacial till
Elevation: 3,700 to 4,400 feet
Native plants: Ponderosa pine, white fir, snowbrush, chinkapin, pinegrass
Climatic factors:

Mean annual precipitation—50 to 60 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—20 to 50 days

Typical Profile

1 inch to 0—organic mat
0 to 16 inches—very dark brown fine sandy loam
16 to 24 inches—very dark brown and black loamy fine sand and fine sand
24 to 65 inches—dark yellowish brown extremely stony sandy loam

Soil Properties and Qualities

Depth: Glacial till at a depth of 20 to 40 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 6 inches

Contrasting Inclusions

- Douthit soils on side slopes
- Linksterly soils on side slopes
- Rock outcrop on ridges

Major Use

Woodland

Major Management Limitations

Slope, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical or chemical treatment or by livestock grazing.
- Wheeled and tracked equipment can be used; however, cable yarding generally is safer and disturbs the soil less.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the susceptibility to compaction, all ground operations, including tractor skidding, mechanical harvesting, and machine piling, should be avoided unless the surface layer is frozen or covered with snow. Subsoiling can be used to loosen the compacted layer.

Forest Service Plant Association

CW-C2-12

14C—Belrick fine sandy loam, cool, 0 to 15 percent slopes

Composition

Belrick soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landform: Moraines
Parent material: Ash over glacial till
Elevation: 4,400 to 5,200 feet
Native plants: Ponderosa pine, Douglas fir, common snowberry, forbs
Climatic factors:
Mean annual precipitation—60 to 70 inches
Mean annual air temperature—35 to 42 degrees F
Frost-free period—10 to 30 days

Typical Profile

1 inch to 0—organic mat
0 to 16 inches—very dark brown fine sandy loam
16 to 24 inches—very dark brown and black loamy fine sand and fine sand
24 to 65 inches—dark yellowish brown extremely stony sandy loam

Soil Properties and Qualities

Depth: Glacial till at a depth of 20 to 40 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 6 inches

Contrasting Inclusions

- Douthit soils on side slopes and ridges
- Linksterly soils on side slopes

Major Use

Woodland

Major Management Limitations

Frost heaving, low fertility, susceptibility to compaction

General Management Considerations

- Severe frost or frost heaving can damage or kill seedlings.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical or chemical treatment or by livestock grazing.

- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the susceptibility to compaction, all ground operations, including tractor skidding, mechanical harvesting, and machine piling, should be avoided unless the surface layer is frozen or covered with snow. Subsoiling can be used to loosen the compacted layer.

Forest Service Plant Association

CD-S6-13

15C—Belrick fine sandy loam, dry, 0 to 15 percent slopes

Composition

Belrick soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Moraines
Parent material: Ash over glacial till
Elevation: 3,700 to 4,000 feet
Native plants: Ponderosa pine, sedges, Idaho fescue, peavine
Climatic factors:
Mean annual precipitation—50 to 60 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—20 to 50 days

Typical Profile

1 inch to 0—organic mat
0 to 16 inches—very dark brown fine sandy loam
16 to 24 inches—very dark brown and black loamy fine sand and fine sand
24 to 65 inches—dark yellowish brown extremely stony sandy loam

Soil Properties and Qualities

Depth: Glacial till at a depth of 20 to 40 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 6 inches

Contrasting Inclusions

- Douthit soils on side slopes
- Linksterly soils on side slopes

Major Use

Woodland

Major Management Limitations

Low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical or chemical treatment or by livestock grazing.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the susceptibility to compaction, all ground operations, including tractor skidding, mechanical harvesting, and machine piling, should be avoided unless the surface layer is frozen or covered with snow. Subsoiling can be used to loosen the compacted layer.

Forest Service Plant Association

CP-G2-12

16E—Belrick-Douthit complex, 30 to 50 percent slopes

Composition

Belrick soil and similar inclusions—45 percent
Douthit soil and similar inclusions—40 percent
Contrasting inclusions—15 percent

Setting

Landscape position: Belrick soil—north-facing slopes; Douthit soil—south-facing slopes
Landform: Moraines
Parent material: Ash over glacial till
Elevation: 3,700 to 5,200 feet
Native plants: Belrick soil—ponderosa pine, white fir, snowbrush, chinkapin, pinegrass; Douthit soil—ponderosa pine, Douglas fir, common snowberry, forbs
Climatic factors:
Mean annual precipitation—50 to 60 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—20 to 50 days

Typical Profile of the Belrick Soil

1 inch to 0—organic mat
0 to 16 inches—very dark brown fine sandy loam
16 to 24 inches—very dark brown and black loamy fine sand and fine sand
24 to 65 inches—dark yellowish brown extremely stony sandy loam

Properties and Qualities of the Belrick Soil

Depth: Glacial till at a depth of 20 to 40 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 6 inches

Typical Profile of the Douthit Soil

2 inches to 0—organic mat
0 to 3 inches—very dark grayish brown sandy loam
3 to 12 inches—dark yellowish brown cobbly sandy loam
12 to 62 inches—dark brown extremely stony sandy loam

Properties and Qualities of the Douthit Soil

Depth: Glacial till at a depth of 10 to 20 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 5 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 20 to 40 inches
- Linksterly soils on side slopes
- Rock outcrop on ridges

Major Use

Woodland

Major Management Limitations

Slope, low fertility, susceptibility to compaction

General Management Considerations

- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Machinery should be used only in areas covered with logging slash or brush to reduce soil displacement.
- Because of the susceptibility to compaction, all ground operations, including tractor skidding, mechanical harvesting, and machine piling, should be avoided unless the surface layer is frozen or covered with snow. Subsoiling can be used to loosen the compacted layer.

Forest Service Plant Association

Belrick soil—CW-C2-12
Douthit soil—CD-S6-13

17A—Blayden loamy sand, 0 to 3 percent slopes

Composition

Blayden soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Old alluvium derived from basalt with ash on the surface
Elevation: 4,100 to 4,800 feet
Native plants: Wyoming big sagebrush, Idaho fescue, western needlegrass, Thurber needlegrass, Indian ricegrass
Climatic factors:
  Mean annual precipitation—10 to 12 inches
  Mean annual air temperature—43 to 45 degrees F
  Frost-free period—50 to 90 days

Typical Profile

0 to 3 inches—grayish brown loamy sand
3 to 15 inches—brown and pale brown gravelly loam
15 to 60 inches—indurated duripan

Soil Properties and Qualities

Depth: Duripan at a depth of 12 to 20 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate above the duripan
Available water capacity: About 3 inches

Contrasting Inclusions

- Menbo soils on toe slopes of hills
- Stookmoor soils along adjacent lava plains
- Borobey and Gardone soils in drainageways

Major Use

Livestock grazing

Major Management Limitations

Climate, surface texture, soil depth

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth.
- The low annual precipitation and restricted soil depth limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.

Range Site

Gravelly Terrace 9-11pz

18D—Bluesters gravelly sandy loam, 15 to 50 percent slopes

Composition

Bluesters soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: North- and south-facing slopes of cinder cones
Parent material: Ash over cinders
Elevation: 3,000 to 5,500 feet
Native plants: Western juniper, ponderosa pine, mountain big sagebrush, antelope bitterbrush, Idaho fescue, bluebunch wheatgrass
Climatic factors:
  Mean annual precipitation—12 to 18 inches
  Mean annual air temperature—42 to 47 degrees F
  Frost-free period—60 to 90 days

Typical Profile

0 to 16 inches—dark brown gravelly sandy loam
16 to 60 inches—black and reddish brown cinders

Soil Properties and Qualities

Depth: Cinders at a depth of 14 to 30 inches; bedrock at a depth of 60 inches or more
Drainage class: Excessively drained
Permeability: Moderately rapid over very rapid
Available water capacity: About 2 inches

Contrasting Inclusions

- Fryrear soils on side slopes
- Rock outcrop

Major Uses

Livestock grazing, woodland

Major Management Limitations

Climate, permeability, slope, aspect, rooting depth, low fertility, susceptibility to compaction

General Management Considerations

Livestock grazing

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Pond development is limited by the risk of seepage and steepness of slope.
- The steepness of slope restricts the distribution of livestock and limits range seeding with ground equipment.
- The steep, south-facing slopes are less suited to grazing in hot periods during the grazing season.

Woodland

- The seedling survival rate is poor because of the low precipitation and low available water capacity.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because this coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Range Site

Juniper-Pine-Fescue

19A—Borobey sandy loam, 0 to 5 percent slopes

Composition

Borobey soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash over old alluvium
Elevation: 4,200 to 4,800 feet
Native plants: Mountain big sagebrush, Idaho fescue, Thurber needlegrass, western needlegrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 21 inches—grayish brown and brown sandy loam
21 to 51 inches—pale brown sandy loam
51 to 60 inches—pale brown clay loam

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Moderately slow
Available water capacity: About 5 inches

Contrasting Inclusions

- Reluctan soils on higher toe slopes
- Ninemile soils on lava plains
- Stookmoor soils along adjacent lava plains
- Gardone and Dester soils in drainageways

Major Use

Livestock grazing

Major Management Limitations

Climate, surface texture, permeability

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Pumice 8-10pz

20A—Borobey gravelly sandy loam, hardpan substratum, 0 to 5 percent slopes

Composition

Borobey soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash over old alluvium
Elevation: 4,200 to 4,800 feet
Native plants: Mountain big sagebrush, western needlegrass, Ross sedge, bottlebrush squirreltail
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 8 inches—grayish brown gravelly sandy loam
8 to 24 inches—pale brown loamy sand
24 to 45 inches—pale brown sandy loam
45 to 60 inches—indurated duripan

Soil Properties and Qualities

Depth: Duripan at a depth of 40 to 60 inches; bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Moderately slow above the duripan
Available water capacity: About 4 inches

Contrasting Inclusions

- Ninemile soils on lava plains
- Stookmoor soils along adjacent lava plains
- Gardone and Dester soils in drainageways

Major Use

Livestock grazing

Major Management Limitations

Climate, surface texture, soil depth

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Pumice Flat 9-11pz

21C—Bott-Douthit complex, 0 to 15 percent slopes

Composition

Bott soil and similar inclusions—60 percent
Douthit soil and similar inclusions—30 percent
Contrasting inclusions—10 percent

Setting

Landform: Bott soil—mountains; Douthit soil—moraines
Parent material: Bott soil—ash over colluvium; Douthit soil—ash over glacial till
Elevation: 3,700 to 5,000 feet
Native plants: Bott soil—ponderosa pine, Douglas fir, snowbrush, chinkapin, brackenfern; Douthit soil—ponderosa pine, Douglas fir, common snowberry, forbs
Climatic factors:
Mean annual precipitation—50 to 70 inches
Mean annual air temperature—35 to 42 degrees F
Frost-free period—10 to 50 days

Typical Profile of the Bott Soil

1 inch to 0—organic mat
0 to 10 inches—dark yellowish brown gravelly sandy loam
10 to 23 inches—dark yellowish brown sandy loam
23 to 62 inches—dark brown very stony loam

Properties and Qualities of the Bott Soil

Depth: Colluvium at a depth of 20 to 30 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 8 inches

Typical Profile of the Douthit Soil

2 inches to 0—organic mat
0 to 3 inches—very dark grayish brown sandy loam
3 to 12 inches—dark yellowish brown cobbly sandy loam
12 to 62 inches—dark brown extremely stony sandy loam

Properties and Qualities of the Douthit Soil

Depth: Glacial till at a depth of 10 to 20 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid over very rapid
Available water capacity: About 5 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 20 to 40 inches
- Minkwell soils on side slopes and toe slopes
- Rock outcrop on ridges

Major Use

Woodland

Major Management Limitations

Low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

Bott soil—CW-C2-11
Douthit soil—CD-S6-13

21D—Bott-Douthit complex, 15 to 30 percent slopes

Composition

Bott soil and similar inclusions—60 percent
Douthit soil and similar inclusions—30 percent
Contrasting inclusions—10 percent

Setting

Landform: Bott soil—mountains; Douthit soil—moraines
Parent material: Bott soil—ash over colluvium; Douthit soil—ash over glacial till
Elevation: 3,700 to 5,000 feet
Native plants: Bott soil—ponderosa pine, Douglas fir, snowbrush, chinkapin, brackenfern; Douthit soil—ponderosa pine, Douglas fir, common snowberry, forbs

Climatic factors:
Mean annual precipitation—50 to 70 inches
Mean annual air temperature—35 to 42 degrees F
Frost-free period—10 to 50 days

Typical Profile of the Bott Soil

1 inch to 0—organic mat
0 to 10 inches—dark yellowish brown gravelly sandy loam
10 to 23 inches—dark yellowish brown sandy loam
23 to 62 inches—dark brown very stony loam

Properties and Qualities of the Bott Soil

Depth: Colluvium at a depth of 20 to 30 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 8 inches

Typical Profile of the Douthit Soil

2 inches to 0—organic mat
0 to 3 inches—very dark grayish brown sandy loam
3 to 12 inches—dark yellowish brown cobbly sandy loam
12 to 62 inches—dark brown extremely stony sandy loam

Properties and Qualities of the Douthit Soil

Depth: Glacial till at a depth of 10 to 20 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid over very rapid
Available water capacity: About 5 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 20 to 40 inches
- Minkwell soils on side slopes and toe slopes
- Rock outcrop on ridges

Major Use

Woodland

Major Management Limitations

Slope, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Wheeled and tracked equipment can be used; however, cable yarding generally is safer and disturbs the soil less.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

Bott soil—CW-C2-11
Douthit soil—CD-S6-13

22E—Bott-Kweo complex, 30 to 50 percent slopes

Composition

Bott soil and similar inclusions—55 percent
Kweo soil and similar inclusions—35 percent
Contrasting inclusions—10 percent

Setting

Landform: Bott soil—mountains; Kweo soil—cinder cones
Parent material: Bott soil—ash over colluvium; Kweo soil—ash over cinders
Elevation: 3,700 to 5,000 feet
Native plants: Bott soil—ponderosa pine, Douglas fir, snowbrush, chinkapin, brackenfern; Kweo soil—ponderosa pine, Douglas fir, common snowberry, forbs
Climatic factors:
Mean annual precipitation—50 to 70 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—20 to 50 days

Typical Profile of the Bott Soil

1 inch to 0—organic mat
0 to 10 inches—dark yellowish brown gravelly sandy loam
10 to 23 inches—dark yellowish brown sandy loam
23 to 62 inches—dark brown very stony loam

Properties and Qualities of the Bott Soil

Depth: Colluvium at a depth of 20 to 30 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained

Permeability: Moderate
Available water capacity: About 8 inches

Typical Profile of the Kweo Soil

1 inch to 0—organic mat
0 to 13 inches—dark brown gravelly sandy loam
13 to 25 inches—dark reddish brown very gravelly sandy loam
25 to 60 inches—dark yellowish brown cinders

Properties and Qualities of the Kweo Soil

Depth: Cinders at a depth of 20 to 35 inches; bedrock at a depth of 60 inches or more
Drainage class: Excessively drained
Permeability: Moderately rapid over very rapid
Available water capacity: About 3 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 40 to 60 inches
- Rock outcrop on ridges

Major Use

Woodland

Major Management Limitations

Bott and Kweo soils—slope, low fertility, susceptibility to compaction
Kweo soil—rooting depth, rock fragments in surface layer

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because the coarse-textured Kweo soil has insufficient anchoring capability, trees on this soil are subject to windthrow.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- To minimize soil displacement, machinery should be used only in areas covered with logging slash or brush.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

Bott soil—CW-C2-11
Kweo soil—CD-S6-13

23A—Buckbert sandy loam, 0 to 3 percent slopes

Composition

Buckbert soil and similar inclusions—95 percent
Contrasting inclusions—5 percent

Setting

Landform: Hills
Parent material: Ash over alluvium
Elevation: 2,500 to 2,800 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—70 to 100 days

Typical Profile

0 to 21 inches—brown sandy loam
21 to 52 inches—pale brown loam
52 to 60 inches—yellowish brown sandy loam

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 9 inches

Contrasting Inclusions

- Redmond soils on side slopes

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Surface texture, permeability

General Management Considerations

Irrigated cropland

- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.

Range Site

Pumice Flat 10-12pz

24A—Caphealy-Reuter complex, 0 to 3 percent slopes

Composition

Caphealy soil and similar inclusions—45 percent
Reuter soil and similar inclusions—45 percent
Contrasting inclusions—10 percent

Setting

Landform: Hills
Parent material: Colluvium over semiconsolidated sediment
Elevation: 2,000 to 3,200 feet
Native plants: Caphealy soil—western juniper, basin big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue; Reuter soil—Wyoming big sagebrush, bluebunch wheatgrass, Thurber needlegrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—8 to 11 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—110 to 140 days

Typical Profile of the Caphealy Soil

0 to 16 inches—grayish brown and brown sandy loam
16 to 19 inches—brown coarse sandy loam
19 to 23 inches—brown gravelly coarse sand
23 to 26 inches—weathered, fractured tuff
26 inches—welded tuff of the Deschutes Formation

Properties and Qualities of the Caphealy Soil

Depth: Soft bedrock at a depth of 20 to 38 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Typical Profile of the Reuter Soil

0 to 12 inches—brown sandy loam
12 to 24 inches—weathered, fractured tuff
24 inches—welded tuff of the Deschutes Formation

Properties and Qualities of the Reuter Soil

Depth: Soft bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 1 inch

Contrasting Inclusions

- Lickskillet soils on hills
- Era soils in swales

Major Uses

Livestock grazing, irrigated cropland

Major Management Limitations

Surface texture, soil depth, available water capacity

General Management Considerations

Livestock grazing

- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- The low available water capacity of the soils and the restricted depth of the Reuter soil limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.

Irrigated cropland

- Because the surface layer is sandy loam, these soils are subject to wind erosion if left unprotected.
- Because of the low available water capacity of these soils, intensive irrigation water management is needed.

Range Site

Caphealy soil—Droughty Loam 8-10pz
Reuter soil—Droughty 8-12pz

24B—Caphealy-Reuter complex, 3 to 8 percent slopes

Composition

Caphealy soil and similar inclusions—45 percent
Reuter soil and similar inclusions—45 percent
Contrasting inclusions—10 percent

Setting

Landform: Hills
Parent material: Colluvium over semiconsolidated sediment
Elevation: 2,000 to 3,200 feet

Native plants: Caphealy soil—western juniper, basin big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue; Reuter soil—Wyoming big sagebrush, bluebunch wheatgrass, Thurber needlegrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—8 to 11 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—110 to 140 days

Typical Profile of the Caphealy Soil

0 to 16 inches—grayish brown and brown sandy loam
16 to 19 inches—brown coarse sandy loam
19 to 23 inches—brown gravelly coarse sand
23 to 26 inches—weathered, fractured tuff
26 inches—welded tuff of the Deschutes Formation

Properties and Qualities of the Caphealy Soil

Depth: Soft bedrock at a depth of 20 to 38 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Typical Profile of the Reuter Soil

0 to 12 inches—brown sandy loam
12 to 24 inches—weathered, fractured tuff
24 inches—welded tuff of the Deschutes Formation

Properties and Qualities of the Reuter Soil

Depth: Soft bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 1 inch

Contrasting Inclusions

- Lickskillet soils on hills
- Era soils in swales

Major Uses

Livestock grazing, irrigated cropland

Major Management Limitations

Surface texture, soil depth, available water capacity, slope

General Management Considerations

Livestock grazing

- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- The low available water capacity of the soils and the restricted depth of the Reuter soil limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.

Irrigated cropland

- Because the surface layer is sandy loam, these soils are subject to wind erosion if left unprotected.
- Because of the low available water capacity of these soils, intensive irrigation water management is needed.
- Because of the steepness of slope, sprinkler irrigation systems should be used to minimize runoff.

Range Site

Caphealy soil—Droughty Loam 8-10pz
Reuter soil—Droughty 8-12pz

24C—Caphealy-Reuter complex, 8 to 15 percent slopes

Composition

Caphealy soil and similar inclusions—45 percent
Reuter soil and similar inclusions—45 percent
Contrasting inclusions—10 percent

Setting

Landform: Hills
Parent material: Colluvium over semiconsolidated sediment
Elevation: 2,000 to 3,200 feet
Native plants: Caphealy soil—western juniper, basin big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue; Reuter soil—Wyoming big sagebrush, bluebunch wheatgrass, Thurber needlegrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—8 to 11 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—110 to 140 days

Typical Profile of the Caphealy Soil

0 to 16 inches—grayish brown and brown sandy loam
16 to 19 inches—brown coarse sandy loam
19 to 23 inches—brown gravelly coarse sand
23 to 26 inches—weathered, fractured tuff
26 inches—welded tuff of the Deschutes Formation

Properties and Qualities of the Caphealy Soil

Depth: Soft bedrock at a depth of 20 to 38 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Typical Profile of the Reuter Soil

0 to 12 inches—brown sandy loam

12 to 24 inches—weathered, fractured tuff
24 inches—welded tuff of the Deschutes Formation

Properties and Qualities of the Reuter Soil

Depth: Soft bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 1 inch

Contrasting Inclusions

- Lickskillet soils on hills
- Era soils in swales

Major Uses

Livestock grazing, irrigated cropland

Major Management Limitations

Surface texture, soil depth, available water capacity, slope

General Management Considerations

Livestock grazing

- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- The low available water capacity of the soils and the restricted depth of the Reuter soil limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- Pond development is limited by the steepness of slope.

Irrigated cropland

- Because the surface layer is sandy loam, these soils are subject to wind erosion if left unprotected.
- Intensive irrigation water management is needed because of the low available water capacity.
- Because of the steepness of slope, sprinkler irrigation systems should be used to minimize runoff.

Range Site

Caphealy soil—Droughty Loam 8-10pz
Reuter soil—Droughty 8-12pz

24D—Caphealy-Reuter complex, 15 to 30 percent slopes

Composition

Caphealy soil and similar inclusions—45 percent
Reuter soil and similar inclusions—45 percent
Contrasting inclusions—10 percent

Setting

Landform: Hills
Parent material: Colluvium over semiconsolidated sediment
Elevation: 2,000 to 3,200 feet
Native plants: Western juniper, Wyoming big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—8 to 11 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—110 to 140 days

Typical Profile of the Caphealy Soil

0 to 16 inches—grayish brown and brown sandy loam
16 to 19 inches—brown coarse sandy loam
19 to 23 inches—brown gravelly coarse sand
23 to 26 inches—weathered, fractured tuff
26 inches—welded tuff of the Deschutes Formation

Properties and Qualities of the Caphealy Soil

Depth: Soft bedrock at a depth of 20 to 38 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Typical Profile of the Reuter Soil

0 to 12 inches—brown sandy loam
12 to 24 inches—weathered, fractured tuff
24 inches—welded tuff of the Deschutes Formation

Properties and Qualities of the Reuter Soil

Depth: Soft bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 1 inch

Contrasting Inclusions

- Lickskillet soils on hills
- Era soils in swales

Major Use

Livestock grazing

Major Management Limitations

Surface texture, soil depth, available water capacity, slope

General Management Considerations

- Care should be taken to protect the soils from wind erosion when applying range improvement practices.

- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- The low available water capacity of the soils and the restricted depth of the Reuter soil limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- Pond development is limited by the steepness of slope.

Range Site

South 9-12pz

25C—Choptie-Westbutte complex, 5 to 20 percent slopes

Composition

Choptie soil and similar inclusions—50 percent
Westbutte soil and similar inclusions—40 percent
Contrasting inclusions—10 percent

Setting

Landform: Hills
Parent material: Residuum and colluvium derived from basalt or welded tuff with ash on the surface
Elevation: 4,000 to 5,500 feet
Native plants: Antelope bitterbrush, mountain big sagebrush, common snowberry, Idaho fescue, bluebunch wheatgrass
Climatic factors:
Mean annual precipitation—12 to 14 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile of the Choptie Soil

0 to 15 inches—grayish brown and brown loam
15 to 19 inches—brown gravelly loam
19 inches—welded tuff

Properties and Qualities of the Choptie Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 3 inches

Typical Profile of the Westbutte Soil

0 to 9 inches—very dark grayish brown stony loam
9 to 21 inches—dark brown very cobbly loam
21 to 30 inches—brown very cobbly clay loam
30 inches—welded tuff

Properties and Qualities of the Westbutte Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 4 inches

Contrasting Inclusions

- Very shallow soils
- Rock outcrop on knolls

Major Use

Livestock grazing

Major Management Limitations

Climate, soil depth, rock fragments in surface layer, slope

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Pond development is limited by the soil depth and steepness of slope.
- Shallow rooting depth of the Choptie soil limits the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Shrubby Mountain Clayey 12-16pz

26A—Clinefalls sandy loam, 0 to 3 percent slopes

Composition

Clinefalls soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landform: Stream terraces
Parent material: Ash over alluvium
Elevation: 2,500 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread
Climatic factors:
Mean annual precipitation—10 to 12 inches

Mean annual air temperature—47 to 52 degrees F
Frost-free period—70 to 100 days

Typical Profile

0 to 15 inches—dark grayish brown and grayish brown sandy loam
15 to 20 inches—grayish brown gravelly sandy loam
20 to 25 inches—brown very gravelly loamy sand
25 to 60 inches—dark gray, stratified extremely gravelly sand and sand

Soil Properties and Qualities

Depth: Stratified sand and gravel at a depth of 20 to 40 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid over very rapid
Available water capacity: About 3 inches

Contrasting Inclusions

- Deschutes soils in swales
- Lafollette soils on terraces
- Poorly drained soils along drainageways

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Surface texture, permeability

General Management Considerations

Irrigated cropland

- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.
- Applied fertilizers and chemicals may be leached and ground water may be contaminated because of the very rapid permeability of the substratum.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.

Range Site

Pumice Flat 10-12pz

27A—Clovkamp loamy sand, 0 to 3 percent slopes

Composition

Clovkamp soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Old stream terraces on lava plains
Parent material: Ash over alluvium
Elevation: 3,000 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—70 to 100 days

Typical Profile

0 to 12 inches—grayish brown and brown loamy sand
12 to 24 inches—brown loamy sand
24 to 40 inches—pale brown gravelly loamy fine sand
40 to 60 inches—pale brown extremely gravelly sand

Soil Properties and Qualities

Depth: Extremely gravelly layer at a depth of 35 to 50 inches; bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Rapid over moderate
Available water capacity: About 5 inches

Contrasting Inclusions

- Deskamp soils on side slopes

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Surface texture, permeability

General Management Considerations

Irrigated cropland

- Because the surface layer is loamy sand, this soil is subject to wind erosion if left unprotected.
- Because of the surface texture, the water infiltration

rate is high, which limits the type of irrigation system that can be used.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.

Range Site

Pumice Flat 10-12pz

28A—Clovkamp loamy sand, bedrock substratum, 0 to 3 percent slopes

Composition

Clovkamp soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Old stream terraces on lava plains
Parent material: Ash over alluvium
Elevation: 3,000 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread
Climatic factors:
  Mean annual precipitation—10 to 12 inches
  Mean annual air temperature—47 to 52 degrees F
  Frost-free period—70 to 100 days

Typical Profile

0 to 12 inches—grayish brown and brown loamy sand
12 to 24 inches—brown loamy sand
24 to 40 inches—pale brown gravelly loamy fine sand
40 to 50 inches—pale brown extremely gravelly sand
50 inches—basalt

Soil Properties and Qualities

Depth: Extremely gravelly layer at a depth of 35 to 50 inches; bedrock at a depth of 40 to 60 inches
Drainage class: Somewhat excessively drained
Permeability: Rapid over moderate
Available water capacity: About 4 inches

Contrasting Inclusions

- Deskamp soils on side slopes

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Surface texture, permeability

General Management Considerations

Irrigated cropland

- Because the surface layer is loamy sand, this soil is subject to wind erosion if left unprotected.
- Because of the surface texture, the water infiltration rate is high, which limits the type of irrigation system that can be used.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.

Range Site

Pumice Flat 10-12pz

29A—Cryaquolls, 0 to 3 percent slopes

Composition

Cryaquolls and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Pumice-mantled flood plains
Parent material: Mixed alluvium
Elevation: 3,000 to 4,500 feet
Native plants: Willow, birch, sedges, rushes
Climatic factors:
  Mean annual precipitation—15 to 35 inches
  Mean annual air temperature—40 to 45 degrees F
  Frost-free period—10 to 50 days

Representative Profile

1 inch to 0—organic mat
0 to 2 inches—dark brown silt loam
2 to 14 inches—very dark gray loam
14 to 18 inches—very dark gray sandy loam
18 to 60 inches—very dark gray loamy sand and sand

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Very poorly drained and poorly drained
Depth to water table: At the surface to a depth of 24 inches below the surface in November through August
Permeability: Moderate over rapid

Available water capacity: About 7 inches
Flooding: Rare

Contrasting Inclusions

- Soils that are somewhat poorly drained and moderately well drained

Major Uses

Livestock grazing, riparian habitat (fig. 3)

Figure 3.—Riparian habitat in an area of Cryaquolls, 0 to 3 percent slopes. This area is used for grazing.

Major Management Limitations

High water table, climate

General Management Considerations

Livestock grazing

- If seeding is needed, select plants that tolerate seasonal wetness.
- Grazing during wet periods can cause soil compaction and displacement and damage plants.
- The cold climate and soil temperature delay the growth of forage and shorten the growing season.

Range Site

Cold Wet Meadow

30A—Cullius loam, 0 to 3 percent slopes

Composition

Cullius soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Loess over colluvium and semiconsolidated sediment
Elevation: 2,500 to 3,000 feet
Native plants: Western juniper, basin big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
Mean annual precipitation—8 to 11 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—110 to 140 days

Typical Profile

0 to 6 inches—grayish brown loam
6 to 9 inches—grayish brown clay loam
9 to 17 inches—grayish brown clay
17 to 18 inches—weathered, fractured tuff
18 inches—welded tuff of the Deschutes Formation

Soil Properties and Qualities

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Slow
Available water capacity: About 2.5 inches

Contrasting Inclusions

- Era soils in swales
- Madras soils on lava plains
- Soils that are similar to this Cullius soil but are 20 to 40 inches deep to bedrock
- Soils that are similar to this Cullius soil but have a silt loam surface layer

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Soil depth, permeability, climate, available water capacity

General Management Considerations

Irrigated cropland

- Because this soil is shallow, intensive irrigation water management is needed for crop production.
- Because water-soluble chemicals can be carried in the runoff, care should be taken to prevent excessive irrigation rates that result in overland flow.

Livestock grazing

- Pond development is limited by the soil depth.
- The low annual precipitation, low available water capacity, and restricted soil depth limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.

Range Site

Droughty Loam 8-10pz

30B—Cullius loam, 3 to 8 percent slopes

Composition

Cullius soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Loess over colluvium and semiconsolidated sediment
Elevation: 2,500 to 3,000 feet
Native plants: Western juniper, basin big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
Mean annual precipitation—8 to 11 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—110 to 140 days

Typical Profile

0 to 6 inches—grayish brown loam
6 to 9 inches—grayish brown clay loam
9 to 17 inches—grayish brown clay
17 to 18 inches—weathered, fractured tuff
18 inches—welded tuff of the Deschutes Formation

Soil Properties and Qualities

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Slow
Available water capacity: About 2.5 inches

Contrasting Inclusions

- Era soils in swales
- Madras soils on lava plains
- Soils that are similar to this Cullius soil but are 20 to 40 inches deep to bedrock
- Soils that are similar to this Cullius soil but have a silt loam surface layer

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Soil depth, permeability, slope, climate, available water capacity

General Management Considerations

Irrigated cropland

- Because this soil is shallow, intensive irrigation water management is needed for crop production.
- Because water-soluble chemicals can be carried in the runoff, care should be taken to prevent excessive irrigation rates that result in overland flow.
- Because of the steepness of slope, sprinkler irrigation systems should be used to minimize runoff.

Livestock grazing

- Pond development is limited by the soil depth.
- The low annual precipitation, low available water capacity, and restricted soil depth limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.

Range Site

Droughty Loam 8-10pz

30C—Cullius loam, 8 to 15 percent slopes

Composition

Cullius soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Loess over colluvium and semiconsolidated sediment
Elevation: 2,500 to 3,000 feet
Native plants: Western juniper, basin big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
Mean annual precipitation—8 to 11 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—110 to 140 days

Typical Profile

0 to 6 inches—grayish brown loam
6 to 9 inches—grayish brown clay loam
9 to 17 inches—grayish brown clay
17 to 18 inches—weathered, fractured tuff
18 inches—welded tuff of the Deschutes Formation

Soil Properties and Qualities

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained

Permeability: Slow
Available water capacity: About 2.5 inches

Contrasting Inclusions

- Era soils in swales
- Madras soils on lava plains
- Soils that are similar to this Cullius soil but are 20 to 40 inches deep to bedrock
- Soils that are similar to this Cullius soil but have a silt loam surface layer

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Soil depth, permeability, slope, climate, available water capacity

General Management Considerations

Irrigated cropland

- Because this soil is shallow, intensive irrigation water management is needed for crop production.
- Because water-soluble chemicals can be carried in the runoff, care should be taken to prevent excessive irrigation rates that result in overland flow.
- Because of the steepness of slope, sprinkler irrigation systems should be used to minimize runoff.

Livestock grazing

- Pond development is limited by the soil depth and steepness of slope.
- The low annual precipitation, low available water capacity, and restricted soil depth limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.

Range Site

Droughty Loam 8-10pz

31A—Deschutes sandy loam, 0 to 3 percent slopes

Composition

Deschutes soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 2,500 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—70 to 90 days

Typical Profile

0 to 17 inches—grayish brown sandy loam
17 to 31 inches—light grayish brown sandy loam
31 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 4 inches

Contrasting Inclusions

- Soils that have a loamy sand or gravelly sandy loam surface layer
- Redmond soils in swales
- Stukel soils on ridges
- Rock outcrop

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Soil depth, surface texture, permeability

General Management Considerations

Irrigated cropland

- Well-managed irrigation systems are needed for deep-rooted crops such as alfalfa.
- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.
- The included areas of Rock outcrop limit the areas suitable for crops and restrict farming operations.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and risk of seepage.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Pumice Flat 10-12pz

31B—Deschutes sandy loam, 3 to 8 percent slopes

Composition

Deschutes soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 2,500 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—70 to 90 days

Typical Profile

0 to 17 inches—grayish brown sandy loam
17 to 31 inches—light grayish brown sandy loam
31 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 4 inches

Contrasting Inclusions

- Soils that have a loamy sand or gravelly sandy loam surface layer
- Redmond soils in swales
- Stukel soils on ridges
- Rock outcrop

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Soil depth, surface texture, permeability, slope

General Management Considerations

Irrigated cropland

- Well-managed irrigation systems are needed for deep-rooted crops such as alfalfa.
- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.
- The included areas of Rock outcrop limit the areas suitable for crops and restrict farming operations.
- Because of the steepness of slope, sprinkler irrigation systems should be used to minimize runoff.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and risk of seepage.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Pumice Flat 10-12pz

32A—Deschutes sandy loam, dry, 0 to 3 percent slopes

Composition

Deschutes soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 2,500 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, needleandthread, Idaho fescue, western needlegrass
Climatic factors:
Mean annual precipitation—8 to 10 inches
Mean annual air temperature—49 to 52 degrees F
Frost-free period—80 to 100 days

Typical Profile

0 to 17 inches—grayish brown sandy loam
17 to 31 inches—light grayish brown sandy loam
31 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 4 inches

Contrasting Inclusions

- Soils that have a loamy sand or gravelly sandy loam surface layer

- Redmond soils in swales
- Stukel soils on ridges
- Rock outcrop

Major Uses

Irrigated cropland, livestock grazing (fig. 4)

Figure 4.—Irrigated pasture and rangeland in an area of Deschutes sandy loam, dry, 0 to 3 percent slopes, in foreground. Lickskillet and Redcliff soils in background.

Major Management Limitations

Soil depth, surface texture, climate

General Management Considerations

Irrigated cropland

- Well-managed irrigation systems are needed for deep-rooted crops such as alfalfa.
- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.
- The included areas of Rock outcrop limit the areas suitable for crops and restrict farming operations.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and risk of seepage.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Pumice Flat 8-10pz

33B—Deschutes-Houstake complex, 0 to 8 percent slopes

Composition

Deschutes soil and similar inclusions—50 percent
Houstake soil and similar inclusions—35 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 2,500 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, needleandthread, Idaho fescue, western needlegrass
Climatic factors:
  Mean annual precipitation—8 to 10 inches
  Mean annual air temperature—49 to 52 degrees F
  Frost-free period—80 to 100 days

Typical Profile of the Deschutes Soil

0 to 17 inches—grayish brown sandy loam
17 to 31 inches—light grayish brown sandy loam
31 inches—basalt

Properties and Qualities of the Deschutes Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 4 inches

Typical Profile of the Houstake Soil

0 to 5 inches—brown sandy loam
5 to 22 inches—brown sandy loam
22 to 60 inches—light brownish gray and brown sandy loam

Properties and Qualities of the Houstake Soil

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 7 inches

Contrasting Inclusions

- Redmond soils in swales
- Soils that have a loamy sand surface layer
- Rock outcrop

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Deschutes and Houstake soils—surface texture, permeability, slope, climate
Deschutes soil—soil depth

General Management Considerations

Irrigated cropland

- On the Deschutes soil, well-managed irrigation systems are needed for deep-rooted crops such as alfalfa.
- Because the surface layer is sandy loam, the soils in this unit are subject to wind erosion if left unprotected.
- The included areas of Rock outcrop limit the areas suitable for crops and restrict farming operations.
- Because of the steepness of slope and undulating topography, sprinkler irrigation systems are best suited to this unit.

Livestock grazing

- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and risk of seepage.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Pumice Flat 8-10pz

34C—Deschutes-Stukel complex, 0 to 15 percent slopes

Composition

Deschutes soil and similar inclusions—50 percent
Stukel soil and similar inclusions—35 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 2,500 to 4,000 feet
Native plants: Deschutes soil—western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread; Stukel soil—western juniper, mountain big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—70 to 90 days

Typical Profile of the Deschutes Soil

0 to 17 inches—grayish brown sandy loam
17 to 31 inches—light grayish brown sandy loam
31 inches—basalt

Properties and Qualities of the Deschutes Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 4 inches

Typical Profile of the Stukel Soil

0 to 4 inches—grayish brown sandy loam
4 to 11 inches—brown cobbly sandy loam
11 to 18 inches—pale brown gravelly sandy loam
18 inches—basalt

Properties and Qualities of the Stukel Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Contrasting Inclusions

- Redmond soils in swales
- Soils that have a loamy sand surface layer
- Rock outcrop

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Soil depth, surface texture, permeability, slope

General Management Considerations

Irrigated cropland

- Because the Stukel soil is shallow, intensive irrigation water management is needed for crop production.
- Well-managed irrigation systems are needed for deep-rooted crops such as alfalfa.
- Because the surface layer is sandy loam, these soils are subject to wind erosion if left unprotected.
- The included areas of Rock outcrop limit the areas suitable for crops and restrict farming operations.
- Because of the steepness of slope and undulating topography, sprinkler irrigation systems are best suited to this unit.

Livestock grazing

- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth, the risk of seepage, and the steepness of slope in some areas.
- Shallow rooting depth of the Stukel soil limits the choice of species for range seeding to drought-tolerant varieties.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Deschutes soil—Pumice Flat 10-12pz
Stukel soil—Lava Blisters 10-12pz

35B—Deschutes-Stukel complex, dry, 0 to 8 percent slopes

Composition

Deschutes soil and similar inclusions—50 percent
Stukel soil and similar inclusions—35 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 2,500 to 4,000 feet
Native plants: Deschutes soil—western juniper, mountain big sagebrush, needleandthread, Idaho fescue, western needlegrass; Stukel soil—western juniper, mountain big sagebrush, bluebunch wheatgrass, Thurber needlegrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—8 to 10 inches
Mean annual air temperature—49 to 52 degrees F
Frost-free period—80 to 100 days

Typical Profile of the Deschutes Soil

0 to 17 inches—grayish brown sandy loam
17 to 31 inches—light grayish brown sandy loam
31 inches—basalt

Properties and Qualities of the Deschutes Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 4 inches

Typical Profile of the Stukel Soil

0 to 4 inches—grayish brown sandy loam
4 to 11 inches—brown cobbly sandy loam
11 to 18 inches—pale brown gravelly sandy loam
18 inches—basalt

Properties and Qualities of the Stukel Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Contrasting Inclusions

- Redmond soils in swales
- Soils that have a loamy sand surface layer
- Rock outcrop

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Soil depth, surface texture, slope, permeability, climate

General Management Considerations

Irrigated cropland

- Because the Stukel soil is shallow, intensive irrigation water management is needed for crop production.
- Well-managed irrigation systems are needed for deep-rooted crops such as alfalfa.
- Because the surface layer is sandy loam, these soils are subject to wind erosion if left unprotected.
- The included areas of Rock outcrop limit the areas suitable for crops and restrict farming operations.

- Because of the steepness of slope and undulating topography, sprinkler irrigation systems are best suited to this unit.

Livestock grazing

- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and risk of seepage.
- The low annual precipitation and restricted depth of the Stukel soil limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Deschutes soil—Pumice Flat 8-10pz
Stukel soil—Lava Blisters 8-10pz

36A—Deskamp loamy sand, 0 to 3 percent slopes

Composition

Deskamp soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 3,000 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—70 to 90 days

Typical Profile

0 to 17 inches—brown loamy sand
17 to 32 inches—pale brown gravelly loamy sand
32 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Somewhat excessively drained
Permeability: Rapid
Available water capacity: About 3 inches

Contrasting Inclusions

- Clovkamp soils in swales
- Gosney soils on ridges
- Rock outcrop

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Soil depth, surface texture, permeability

General Management Considerations

Irrigated cropland

- Well-managed irrigation systems are needed for deep-rooted crops such as alfalfa.
- Because the surface layer is loamy sand, this soil is subject to wind erosion if left unprotected.
- Because of the surface texture, the water infiltration rate is high, which restricts the type of irrigation system that can be used.
- Applied fertilizers and chemicals may be leached and ground water may be contaminated because of the rapid permeability of the soil.
- The included areas of Rock outcrop limit the areas suitable for crops and restrict farming operations.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and risk of seepage.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Pumice Flat 10-12pz

36B—Deskamp loamy sand, 3 to 8 percent slopes

Composition

Deskamp soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 3,000 to 4,000 feet

Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—70 to 90 days

Typical Profile

0 to 17 inches—brown loamy sand
17 to 32 inches—pale brown gravelly loamy sand
32 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Somewhat excessively drained
Permeability: Rapid
Available water capacity: About 3 inches

Contrasting Inclusions

- Clovkamp soils in swales
- Gosney soils on ridges
- Rock outcrop

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Soil depth, surface texture, permeability, slope

General Management Considerations

Irrigated cropland

- Well-managed irrigation systems are needed for deep-rooted crops such as alfalfa.
- Because the surface layer is loamy sand, this soil is subject to wind erosion if left unprotected.
- Because of the surface texture, the water infiltration rate is high, which restricts the type of irrigation system that can be used.
- Applied fertilizers and chemicals may be leached and ground water may be contaminated because of the rapid permeability of the soil.
- The included areas of Rock outcrop limit the areas suitable for crops and restrict farming operations.
- Because of the steepness of slope, sprinkler irrigation systems should be used to minimize runoff.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and risk of seepage.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Pumice Flat 10-12pz

37B—Deskamp sandy loam, 3 to 8 percent slopes

Composition

Deskamp soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 3,000 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—70 to 90 days

Typical Profile

0 to 17 inches—brown sandy loam
17 to 32 inches—pale brown gravelly loamy sand
32 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Somewhat excessively drained
Permeability: Rapid
Available water capacity: About 3 inches

Contrasting Inclusions

- Soils that have a loamy sand or loamy coarse sand surface layer
- Gosney soils on ridges
- Rock outcrop

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Soil depth, surface texture, permeability, slope

General Management Considerations

Irrigated cropland

- Well-managed irrigation systems are needed for deep-rooted crops such as alfalfa.
- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.
- Applied fertilizers and chemicals may be leached and ground water may be contaminated because of the rapid permeability of the soil.
- The included areas of Rock outcrop limit the areas suitable for crops and restrict farming operations.
- Because of the steepness of slope, sprinkler irrigation systems should be used to minimize runoff.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and risk of seepage.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Pumice Flat 10-12pz

38B—Deskamp-Gosney complex, 0 to 8 percent slopes

Composition

Deskamp soil and similar inclusions—50 percent
Gosney soil and similar inclusions—35 percent
Contrasting inclusions—15 percent

Setting

Landscape position: Deskamp soil—swales; Gosney soil—mounds
Landform: Lava plains
Parent material: Ash
Elevation: 3,000 to 4,000 feet
Native plants: Deskamp soil—western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread; Gosney soil—western juniper, mountain big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—70 to 90 days

Typical Profile of the Deskamp Soil

0 to 17 inches—brown loamy sand
17 to 32 inches—pale brown gravelly loamy sand
32 inches—basalt

Properties and Qualities of the Deskamp Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Somewhat excessively drained
Permeability: Rapid
Available water capacity: About 3 inches

Typical Profile of the Gosney Soil

0 to 2 inches—grayish brown stony loamy sand
2 to 14 inches—grayish brown and pale brown loamy sand
14 inches—basalt

Properties and Qualities of the Gosney Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Somewhat excessively drained
Permeability: Rapid
Available water capacity: About 1 inch

Contrasting Inclusions

- Clovkamp soils in swales
- Soils that are very shallow to bedrock and are on ridges
- Rock outcrop

Major Uses

Livestock grazing, irrigated cropland

Major Management Limitations

Deskamp and Gosney soils—surface texture, soil depth, permeability, slope, available water capacity
Gosney soil—rock fragments in surface layer

General Management Considerations

Livestock grazing

- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and risk of seepage.
- Shallow rooting depth of the Gosney soil limits the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by

the rock fragments on the surface of the Gosney soil.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Irrigated cropland

- Because the surface layer is loamy sand, these soils are subject to wind erosion if left unprotected.
- Because of the surface texture, the water infiltration rate is high, which restricts the type of irrigation system that can be used.
- Applied fertilizers and chemicals may be leached and ground water may be contaminated because of the rapid permeability of the soils.
- Because of the low available water capacity, intensive irrigation water management is needed.
- The rock fragments on the surface of the Gosney soil interfere with farming operations.
- The included areas of Rock outcrop limit the areas suitable for crops and restrict farming operations.
- Because of the steepness of slope and undulating topography, sprinkler irrigation systems are best suited to this unit.

Range Site

Deskamp soil—Pumice Flat 10-12pz
Gosney soil—Lava Blisters 10-12pz

39A—Dester gravelly loamy sand, 0 to 3 percent slopes

Composition

Dester soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash over old alluvium
Elevation: 4,200 to 4,800 feet
Native plants: Mountain big sagebrush, western needlegrass, Ross sedge, bottlebrush squirreltail
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 17 inches—grayish brown gravelly loamy sand
17 to 24 inches—brown clay loam
24 to 34 inches—light yellowish brown gravelly clay loam
34 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 5 inches

Contrasting Inclusions

- Ninemile soils on lava plains
- Borobey soils in small basins and along drainageways
- Choptie soils on knolls and hills

Major Use

Livestock grazing

Major Management Limitations

Climate, surface texture, soil depth

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Pumice Flat 9-11pz

40B—Dester sandy loam, 0 to 8 percent slopes

Composition

Dester soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash over old alluvium
Elevation: 4,200 to 4,800 feet
Native plants: Mountain big sagebrush, Idaho fescue, Thurber needlegrass, western needlegrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical profile

0 to 17 inches—grayish brown sandy loam
17 to 24 inches—brown clay loam
24 to 34 inches—light yellowish brown gravelly clay loam
34 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 5 inches

Contrasting Inclusions

- Ninemile soils on lava plains
- Borobey soils in small basins and along drainageways
- Choptie soils on knolls and hills

Major Use

Livestock grazing

Major Management Limitations

Climate, surface texture, soil depth

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Pumice 8-10pz

41C—Douthit sandy loam, 0 to 15 percent slopes

Composition

Douthit soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Moraines
Parent material: Ash over glacial till
Elevation: 3,700 to 4,400 feet
Native plants: Ponderosa pine, white fir, snowbrush, chinkapin, pinegrass
Climatic factors:
Mean annual precipitation—50 to 60 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—20 to 50 days

Typical Profile

2 inches to 0—organic mat
0 to 3 inches—very dark grayish brown sandy loam
3 to 12 inches—dark yellowish brown cobbly sandy loam
12 to 62 inches—dark brown extremely stony sandy loam

Soil Properties and Qualities

Depth: Glacial till at a depth of 10 to 20 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid over very rapid
Available water capacity: About 5 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 10 to 20 inches
- Belrick soils that are south of Canyon Creek
- Bott soils on side slopes
- Kweo soils on cinder cones

Major Use

Woodland

Major Management Limitations

Low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

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41D—Douthit sandy loam, 15 to 30 percent slopes

Composition

Douthit soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Moraines
Parent material: Ash over glacial till
Elevation: 3,700 to 4,400 feet
Native plants: Ponderosa pine, white fir, snowbrush, chinkapin, pinegrass
Climatic factors:
Mean annual precipitation—50 to 60 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—20 to 50 days

Typical Profile

2 inches to 0—organic mat
0 to 3 inches—very dark grayish brown sandy loam
3 to 12 inches—dark yellowish brown cobbly sandy loam
12 to 62 inches—dark brown extremely stony sandy loam

Soil Properties and Qualities

Depth: Glacial till at a depth of 10 to 20 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid over very rapid
Available water capacity: About 5 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 10 to 20 inches
- Belrick soils that are south of Canyon Creek
- Bott soils on side slopes and ridges
- Kweo soils on cinder cones
- Rock outcrop on ridges

Major Use

Woodland

Major Management Limitations

Slope, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Wheeled and tracked equipment can be used; however, cable yarding generally is safer and disturbs the soil less.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CW-C2-12

41E—Douthit sandy loam, 30 to 50 percent slopes

Composition

Douthit soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Moraines
Parent material: Ash over glacial till
Elevation: 3,700 to 4,400 feet
Native plants: Ponderosa pine, white fir, snowbrush, chinkapin, pinegrass
Climatic factors:
Mean annual precipitation—50 to 60 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—20 to 50 days

Typical Profile

2 inches to 0—organic mat
0 to 3 inches—very dark grayish brown sandy loam
3 to 12 inches—dark yellowish brown cobbly sandy loam
12 to 62 inches—dark brown extremely stony sandy loam

Soil Properties and Qualities

Depth: Glacial till at a depth of 10 to 20 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid over very rapid
Available water capacity: About 5 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 10 to 20 inches
- Belrick soils that are south of Canyon Creek
- Bott soils on side slopes and ridges
- Kweo soils on cinder cones
- Rock outcrop on ridges

Major Use

Woodland

Major Management Limitations

Slope, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Wheeled and tracked equipment can be used; however, cable yarding generally is safer and disturbs the soil less.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CW-C2-12

42C—Douthit sandy loam, cool, 0 to 15 percent slopes

Composition

Douthit soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landform: Moraines
Parent material: Ash over glacial till
Elevation: 4,400 to 5,200 feet
Native plants: Ponderosa pine, Douglas fir, common snowberry, forbs
Climatic factors:
Mean annual precipitation—60 to 70 inches
Mean annual air temperature—35 to 42 degrees F
Frost-free period—10 to 30 days

Typical profile

2 inches to 0—organic mat
0 to 3 inches—very dark grayish brown sandy loam
3 to 12 inches—dark yellowish brown cobbly sandy loam
12 to 62 inches—dark brown extremely stony sandy loam

Soil Properties and Qualities

Depth: Glacial till at a depth of 10 to 20 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid over very rapid
Available water capacity: About 5 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 10 to 20 inches
- Kweo soils on cinder cones

Major Use

Woodland

Major Management Limitations

Low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CD-S6-13

43A—Embal sandy loam, 0 to 3 percent slopes

Composition

Embal soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Alluvial fans, narrow flood plains
Parent material: Alluvium derived from basalt, welded tuff, and ash
Elevation: 4,000 to 4,600 feet
Native plants: Basin big sagebrush, basin wildrye, bluebunch wheatgrass, Idaho fescue
Climatic factors:
  Mean annual precipitation—10 to 12 inches
  Mean annual air temperature—43 to 45 degrees F
  Frost-free period—50 to 90 days

Typical Profile

0 to 20 inches—grayish brown and brown sandy loam
20 to 30 inches—brown sandy loam
30 to 60 inches—grayish brown gravelly sandy loam

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 6 inches

Contrasting Inclusions

- Ninemile soils on lava plains
- Beden soils along drainageways and on side slopes
- Reluctan soils on toe slopes

Major Use

Livestock grazing

Major Management Limitations

Climate, surface texture, permeability

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.

Range Site

Swale 10-14pz

44B—Era sandy loam, 3 to 8 percent slopes

Composition

Era soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landscape position: Foot slopes
Landform: Hills
Parent material: Ash over old alluvium
Elevation: 2,000 to 3,000 feet
Native plants: Western juniper, basin big sagebrush, antelope bitterbrush, needleandthread, Indian ricegrass
Climatic factors:
  Mean annual precipitation—8 to 11 inches
  Mean annual air temperature—47 to 52 degrees F
  Frost-free period—110 to 140 days

Typical Profile

0 to 10 inches—brown sandy loam
10 to 60 inches—pale brown sandy loam

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 7 inches

Contrasting Inclusions

- Soils that are similar to this Era soil but have a very cobbly substratum
- Era soils that have slopes of more than 8 percent
- Caphealy and Reuter soils

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Surface texture, slope, permeability, climate

General Management Considerations

Irrigated cropland

- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.
- Because of the steepness of slope, sprinkler irrigation systems should be used to minimize runoff.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Pumice Hills 8-10pz

45A—Era sandy loam, cobbly substratum, 0 to 3 percent slopes

Composition

Era soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landscape position: Swales
Landform: Hills
Parent material: Ash over old alluvium
Elevation: 2,000 to 3,000 feet
Native plants: Western juniper, basin big sagebrush, antelope bitterbrush, needleandthread, Indian ricegrass
Climatic factors:
Mean annual precipitation—8 to 11 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—110 to 140 days

Typical Profile

0 to 10 inches—brown sandy loam
10 to 42 inches—pale brown sandy loam
42 to 60 inches—pale brown very cobbly sandy loam

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 7 inches

Contrasting Inclusions

- Soils that are similar to this Era soil but have a very cobbly substratum at a depth of less than 40 inches

Major Uses

Irrigated cropland (fig. 5), livestock grazing

Figure 5.—Mint in an area of Era sandy loam, cobbly substratum, 0 to 3 percent slopes.

Major Management Limitations

Surface texture, permeability, climate

General Management Considerations

Irrigated cropland

- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Pumice Hills 8-10pz

46B—Era-Haystack complex, 0 to 8 percent slopes

Composition

Era soil and similar inclusions—45 percent
Haystack soil and similar inclusions—40 percent
Contrasting inclusions—15 percent

Setting

Landform: Alluvial fans
Parent material: Era soil—ash over old alluvium; Haystack soil—colluvium
Elevation: 2,000 to 3,000 feet
Native plants: Era soil—western juniper, basin big sagebrush, antelope bitterbrush, needleandthread, Indian ricegrass; Haystack soil—Wyoming big sagebrush, bluebunch wheatgrass, Thurber needlegrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—8 to 11 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—110 to 140 days

Typical Profile of the Era Soil

0 to 10 inches—brown sandy loam
10 to 42 inches—pale brown sandy loam
42 to 60 inches—pale brown very cobbly sandy loam

Properties and Qualities of the Era Soil

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 7 inches

Typical Profile of the Haystack Soil

0 to 11 inches—dark grayish brown and brown loam
11 to 26 inches—brown very gravelly and extremely gravelly loam
26 to 60 inches—brown extremely gravelly loamy sand

Properties and Qualities of the Haystack Soil

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 3 inches

Contrasting Inclusions

- Soils that are very cobbly throughout

Major Use

Livestock grazing

Major Management Limitations

Surface texture, permeability, climate

General Management Considerations

- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the Era soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Era soil—Pumice Hills 8-10pz
Haystack soil—Droughty 8-12pz

47A—Ermabell loamy fine sand, 0 to 3 percent slopes

Composition

Ermabell soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landform: Stream terraces
Parent material: Ash over glacial outwash
Elevation: 2,800 to 4,000 feet
Native plants: Ponderosa pine, western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, Ross sedge
Climatic factors:
Mean annual precipitation—12 to 18 inches
Mean annual air temperature—42 to 47 degrees F
Frost-free period—60 to 90 days

Typical Profile

0 to 31 inches—grayish brown loamy fine sand
31 to 41 inches—grayish brown fine sand
41 to 60 inches—grayish brown very gravelly sand

Soil Properties and Qualities

Depth: Glacial outwash at a depth of 40 inches or more; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Rapid
Available water capacity: About 5 inches

Contrasting Inclusions

- Lundgren soils on outwash plains
- Omahaling soils on flood plains
- Poorly drained soils on bottoms

Major Use

Livestock grazing

Major Management Limitations

Climate, permeability

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Pond development is limited by the risk of seepage.

Range Site

Pine-Juniper-Bitterbrush-Fescue

48C—Flarm-Smiling complex, 0 to 15 percent slopes

Composition

Flarm soil and similar inclusions—45 percent
Smiling soil and similar inclusions—45 percent
Contrasting inclusions—10 percent

Setting

Landform: Mountains
Parent material: Ash over colluvium
Elevation: 2,500 to 4,000 feet
Native plants: Flarm soil—ponderosa pine, white fir, common snowberry, twinflower; Smiling soil—ponderosa pine, antelope bitterbrush, greenleaf manzanita, Idaho fescue
Climatic factors:
Mean annual precipitation—15 to 25 inches
Mean annual air temperature—40 to 47 degrees F
Frost-free period—60 to 90 days

Typical Profile of the Flarm Soil

4 inches to 0—organic mat
0 to 4 inches—very dark grayish brown loam
4 to 42 inches—dark brown and dark yellowish brown clay loam and gravelly clay loam
42 to 56 inches—dark yellowish brown sandy loam
56 to 65 inches—yellowish brown loam

Properties and Qualities of the Flarm Soil

Depth: Colluvium at a depth of 4 to 7 inches; bedrock at a depth of 60 inches or more
Drainage class: Somewhat poorly drained
Depth to water table: 6 to 24 inches below the surface in April through May
Permeability: Moderately slow
Available water capacity: About 10 inches

Typical Profile of the Smiling Soil

1 inch to 0—organic mat
0 to 16 inches—very dark brown and dark brown sandy loam
16 to 39 inches—dark brown loam
39 to 63 inches—dark brown clay loam

Properties and Qualities of the Smiling Soil

Depth: Colluvium at a depth of 14 to 33 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 10 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 40 to 60 inches
- Soils that are poorly drained or moderately well drained

Major Use

Woodland

Major Management Limitations

Flarm and Smiling soils—low fertility, susceptibility to compaction
Flarm soil—wetness

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- The seasonal high water table in the Flarm soil restricts the use of equipment to midsummer when the soil is dry or to midwinter when the soil is frozen.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the susceptibility to compaction, all ground operations, including tractor skidding, mechanical harvesting, and machine piling, should be avoided on the Flarm soil unless the surface layer is frozen or covered with snow. Subsoiling can be used to loosen the compacted layer.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

Flarm soil—CD-S6-12
Smiling soil—CP-S2-17

49A—Fluvents, 0 to 1 percent slopes

Composition

Fluvents—90 percent
Contrasting inclusions—10 percent

Setting

Landform: Flood plains (fig. 6)

Figure 6.—Area of Fluvents, 0 to 1 percent slopes, along the Crooked River. Smith Rock on right in background.

Parent material: Recent alluvium
Elevation: 1,200 to 1,500 feet
Native plants: Willow, reeds, gray rabbitbrush, green rabbitbrush, big sagebrush
Climatic factors:
Mean annual precipitation—8 to 10 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—110 to 140 days

Representative profile

0 to 4 inches—very dark grayish brown loamy sand
4 to 26 inches—very dark grayish brown sand
26 to 35 inches—dark grayish brown very fine sand
35 to 60 inches—dark brown coarse sand

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained to excessively drained
Permeability: Rapid
Available water capacity: About 5 inches
Flooding: Rare because of upstream flood control

Contrasting Inclusions

- Gravel bars
- Soils that are poorly drained

Major Use

Wildlife habitat

Major Management Limitation

Rare flooding

Range Site

Loamy Bottom

50C—Gap sandy loam, 0 to 15 percent slopes

Composition

Gap soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landform: Mountains
Parent material: Ash over colluvium and residuum
Elevation: 4,000 to 5,000 feet
Native plants: Ponderosa pine, Douglas fir, white fir, common snowberry, pinegrass
Climatic factors:
Mean annual precipitation—25 to 35 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—10 to 50 days

Typical profile:

4 inches to 0—organic mat
0 to 14 inches—dark brown and reddish brown sandy loam
14 to 18 inches—reddish brown loam
18 to 47 inches—dark brown and reddish brown clay loam
47 inches—weathered tuff

Soil Properties and Qualities

Depth: Colluvium at a depth of 14 to 20 inches; soft bedrock at a depth of 40 to 60 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 8 inches

Contrasting Inclusions

- Glaze soils on side slopes

- Prairie soils on side slopes and ridges
- Poorly drained soils in depressions
- Rock outcrop on ridges

Major Use

Woodland

Major Management Limitations

Low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CD-S6-14

51D—Gap-Glaze complex, 15 to 30 percent slopes

Composition

Gap soil and similar inclusions—45 percent
Glaze soil and similar inclusions—40 percent
Contrasting inclusions—15 percent

Setting

Landform: Mountains
Parent material: Ash over colluvium and residuum
Elevation: 4,000 to 5,000 feet
Native plants: Gap soil—ponderosa pine, Douglas fir, white fir, common snowberry, pinegrass; Glaze soil—ponderosa pine, white fir, snowbrush, chinkapin, pinegrass
Climatic factors:
Mean annual precipitation—25 to 35 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—10 to 50 days

Typical Profile of the Gap Soil

4 inches to 0—organic mat
0 to 14 inches—dark brown and reddish brown sandy loam
14 to 18 inches—reddish brown loam
18 to 47 inches—dark brown and reddish brown clay loam
47 inches—weathered tuff

Properties and Qualities of the Gap Soil

Depth: Colluvium at a depth of 14 to 20 inches; soft bedrock at a depth of 40 to 60 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 8 inches

Typical Profile of the Glaze Soil

3 inches to 0—organic mat
0 to 4 inches—dark yellowish brown sandy loam
4 to 19 inches—dark brown cobbly sandy loam
19 to 54 inches—dark brown extremely stony loam
54 inches—weathered tuff

Properties and Qualities of the Glaze Soil

Depth: Colluvium at a depth of 14 to 20 inches; soft bedrock at a depth of 40 to 60 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 5 inches

Contrasting Inclusions

- Prairie soils on side slopes and ridges
- Rock outcrop

Major Use

Woodland

Major Management Limitations

Slope, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Wheeled and tracked equipment can be used; however, cable yarding generally is safer and disturbs the soil less.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

Gap soil—CD-S6-14
Glaze soil—CW-C2-12

52B—Gardone sand, 3 to 10 percent slopes

Composition

Gardone soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 4,200 to 4,800 feet
Native plants: Mountain big sagebrush, Idaho fescue, Thurber needlegrass, western needlegrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 10 inches—dark grayish brown sand
10 to 60 inches—grayish brown and pale brown loamy sand

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Excessively drained
Permeability: Rapid
Available water capacity: About 6 inches

Contrasting Inclusions

- Areas of moderately deep and deep ash deposits over a buried soil on basalt pressure ridges
- Choptie soils on knolls and hills
- Borobey soils along drainageways

Major Use

Livestock grazing

Major Management Limitations

Climate, surface texture, permeability

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Pumice 8-10pz

53C—Gardone sand, hummocky, 3 to 15 percent slopes

Composition

Gardone soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Dunes on lava plains
Parent material: Ash
Elevation: 4,000 to 4,800 feet
Native plants: Mountain big sagebrush, Idaho fescue, Thurber needlegrass, western needlegrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 10 inches—dark grayish brown sand
10 to 60 inches—grayish brown and pale brown loamy sand

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Excessively drained
Permeability: Rapid
Available water capacity: About 6 inches

Contrasting Inclusions

- Borobey soils along drainageways
- Areas of moderately deep and deep ash deposits over a buried soil on basalt pressure ridges
- Stookmoor soils along adjacent lava plains
- Blayden soils along drainageways

Major Use

Livestock grazing

Major Management Limitations

Climate, surface texture, permeability

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Pumice 8-10pz

54C—Gardone sand, moist, 3 to 20 percent slopes

Composition

Gardone soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash over buried soil material
Elevation: 4,000 to 4,800 feet
Native plants: Mountain big sagebrush, antelope bitterbrush, Idaho fescue, Thurber needlegrass, western needlegrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 10 inches—dark grayish brown sand
10 to 41 inches—grayish brown and pale brown loamy sand
41 to 60 inches—pale brown loam

Soil Properties and Qualities

Depth: Buried soil material at a depth of 40 to 60 inches; bedrock at a depth of 60 inches or more
Drainage class: Excessively drained
Permeability: Rapid over moderate
Available water capacity: About 6 inches

Contrasting Inclusions

- Borobey and Blayden soils along drainageways
- Areas of moderately deep ash deposits over a buried soil on basalt pressure ridges
- Stookmoor soils along adjacent lava plains

Major Use

Livestock grazing

Major Management Limitations

Climate, surface texture, permeability

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage and the steepness of slope in some areas.

Range Site

Pumice 10-12pz

55A—Gardone-Borobey complex, 0 to 5 percent slopes

Composition

Gardone soil and similar inclusions—60 percent
Borobey soil and similar inclusions—30 percent
Contrasting inclusions—10 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 4,200 to 4,800 feet
Native plants: Mountain big sagebrush, Idaho fescue, Thurber needlegrass, western needlegrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile of the Gardone Soil

0 to 10 inches—dark grayish brown sand
10 to 60 inches—grayish brown and pale brown loamy sand

Properties and Qualities of the Gardone Soil

Depth: Bedrock at a depth of 60 inches or more

Drainage class: Excessively drained
Permeability: Rapid
Available water capacity: About 6 inches

Typical Profile of the Borobey Soil

0 to 21 inches—grayish brown and brown sandy loam
21 to 51 inches—pale brown sandy loam
51 to 60 inches—pale brown clay loam

Properties and Qualities of the Borobey Soil

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Moderately slow
Available water capacity: About 5 inches

Contrasting Inclusions

- Blayden soils along drainageways
- Rock outcrop along pressure ridges and fault escarpments

Major Use

Livestock grazing

Major Management Limitations

Climate, surface texture, permeability

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Pumice 8-10pz

56E—Glaze-Prairie-Rock outcrop complex, 30 to 50 percent slopes

Composition

Glaze soil and similar inclusions—35 percent
Prairie soil and similar inclusions—35 percent
Rock outcrop—15 percent
Contrasting inclusions—15 percent

Setting

Landform: Mountains
Parent material: Ash over colluvium and residuum
Elevation: 4,000 to 5,000 feet
Native plants: Glaze soil—ponderosa pine, white fir, snowbrush, chinkapin, pinegrass; Prairie soil—ponderosa pine, Douglas fir, white fir, common snowberry, pinegrass
Climatic factors:
  Mean annual precipitation—25 to 35 inches
  Mean annual air temperature—40 to 44 degrees F
  Frost-free period—10 to 50 days

Typical Profile of the Glaze Soil

3 inches to 0—organic mat
0 to 4 inches—dark yellowish brown sandy loam
4 to 19 inches—dark brown cobbly sandy loam
19 to 54 inches—dark brown extremely stony loam
54 inches—weathered tuff

Properties and Qualities of the Glaze Soil

Depth: Colluvium at a depth of 14 to 20 inches; soft bedrock at a depth of 40 to 60 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 5 inches

Typical Profile of the Prairie Soil

3 inches to 0—organic mat
0 to 16 inches—dark brown and dark yellowish brown sandy loam
16 to 22 inches—dark brown gravelly loam
22 to 37 inches—dark brown cobbly loam
37 inches—weathered basalt

Properties and Qualities of the Prairie Soil

Depth: Colluvium at a depth of 14 to 20 inches; soft bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 5 inches

Contrasting Inclusions

- Gap soils on ridges

Major Use

Woodland

Major Management Limitations

Rock outcrop, slope, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the steepness of slope, machinery should be used only in areas covered with logging slash or brush to minimize soil displacement.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

Glaze soil—CW-C2-12
Prairie soil—CD-S6-14

57B—Gosney stony loamy sand, 3 to 8 percent slopes

Composition

Gosney soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 3,000 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—70 to 90 days

Typical Profile

0 to 2 inches—grayish brown stony loamy sand
2 to 14 inches—grayish brown loamy sand
14 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Somewhat excessively drained
Permeability: Rapid
Available water capacity: About 1 inch

Contrasting Inclusions

- Deskamp soils in swales
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Surface texture, soil depth, rock fragments in surface layer

General Management Considerations

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth.
- The restricted soil depth limits the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Lava Blisters 10-12pz

58C—Gosney-Rock outcrop-Deskamp complex, 0 to 15 percent slopes

Composition

Gosney soil and similar inclusions—50 percent
Rock outcrop—25 percent
Deskamp soil and similar inclusions—20 percent
Contrasting inclusions—5 percent

Setting

Landscape position: Gosney soil—mounds; Deskamp soil—swales
Landform: Lava plains
Parent material: Ash
Elevation: 3,000 to 4,000 feet
Native plants: Gosney soil—western juniper, mountain big sagebrush, antelope bitterbrush, bluebunch

wheatgrass, Idaho fescue; Deskamp soil—western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread

Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—70 to 90 days

Typical Profile of the Gosney Soil

0 to 2 inches—grayish brown stony loamy sand
2 to 14 inches—grayish brown and pale brown loamy sand
14 inches—basalt

Properties and Qualities of the Gosney Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Somewhat excessively drained
Permeability: Rapid
Available water capacity: About 1 inch

Typical Profile of the Deskamp Soil

0 to 17 inches—brown loamy sand
17 to 32 inches—pale brown gravelly loamy sand
32 inches—basalt

Properties and Qualities of the Deskamp Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Somewhat excessively drained
Permeability: Rapid
Available water capacity: About 3 inches

Contrasting Inclusions

- Clovkamp soils in swales
- Soils that are very shallow to bedrock

Major Use

Livestock grazing

Major Management Limitations

Rock outcrop, surface texture, soil depth, permeability, rock fragments in surface layer

General Management Considerations

- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth, risk of seepage, and steepness of slope.
- The restricted depth of the Gosney soil limits the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface of the Gosney soil.
- The areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Gosney soil—Lava Blisters 10-12pz
Deskamp soil—Pumice Flat 10-12pz

59C—Gosney-Rock outcrop-Deskamp complex, dry, 0 to 15 percent slopes

Composition

Gosney soil and similar inclusions—50 percent
Rock outcrop—25 percent
Deskamp soil and similar inclusions—20 percent
Contrasting inclusions—5 percent

Setting

Landscape position: Gosney soil—mounds; Deskamp soil—swales
Landform: Lava plains
Parent material: Ash
Elevation: 3,000 to 4,000 feet
Native plants: Gosney soil—western juniper, mountain big sagebrush, bluebunch wheatgrass, Thurber needlegrass, Sandberg bluegrass; Deskamp soil—western juniper, mountain big sagebrush, needleandthread, Idaho fescue, western needlegrass

Climatic factors:
Mean annual precipitation—8 to 10 inches
Mean annual air temperature—49 to 52 degrees F
Frost-free period—80 to 100 days

Typical Profile of the Gosney Soil

0 to 2 inches—grayish brown stony loamy sand
2 to 14 inches—grayish brown and pale brown loamy sand
14 inches—basalt

Properties and Qualities of the Gosney Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Somewhat excessively drained
Permeability: Rapid
Available water capacity: About 1 inch

Typical Profile of the Deskamp Soil

0 to 17 inches—brown loamy sand
17 to 32 inches—pale brown gravelly loamy sand
32 inches—basalt

Properties and Qualities of the Deskamp Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Somewhat excessively drained
Permeability: Rapid
Available water capacity: About 3 inches

Contrasting Inclusions

- Clovkamp soils in swales
- Soils that are very shallow to bedrock

Major Use

Livestock grazing

Major Management Limitations

Rock outcrop, surface texture, soil depth, permeability, rock fragments in surface layer, climate

General Management Considerations

- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth, risk of seepage, and steepness of slope in some areas.
- The restricted depth of the Gosney soil limits the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface of the Gosney soil.
- The areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Gosney soil—Lava Blisters 8-10pz
Deskamp soil—Pumice Flat 8-10pz

60C—Haynap very gravelly loamy coarse sand, 0 to 15 percent slopes

Composition

Haynap soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Moraines
Parent material: Ash and scoria
Elevation: 3,500 to 5,200 feet
Native plants: Ponderosa pine, Douglas fir, common snowberry, forbs
Climatic factors:
Mean annual precipitation—50 to 70 inches
Mean annual air temperature—35 to 42 degrees F
Frost-free period—10 to 50 days

Typical Profile

2 inches to 0—organic mat
0 to 15 inches—black and dark brown very gravelly loamy coarse sand
15 to 29 inches—black extremely gravelly loamy coarse sand
29 to 49 inches—very dark gray and black loamy fine sand
49 to 62 inches—dark brown sandy loam

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Very rapid over moderately rapid
Available water capacity: About 5 inches

Contrasting Inclusions

- Belrick soils on side slopes and ridges
- Linksterly soils on side slopes

Major Use

Woodland

Major Management Limitations

Available water capacity, rock fragments in surface layer, low fertility

General Management Considerations

- Seedlings have a moderate survival rate because of the low available water capacity of the soil.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- The rock fragments in the surface layer restrict the planting of seedlings.

Forest Service Plant Association

CD-S6-13

60D—Haynap very gravelly loamy coarse sand, 15 to 30 percent slopes

Composition

Haynap soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Moraines
Parent material: Ash and scoria
Elevation: 3,500 to 5,200 feet
Native plants: Ponderosa pine, Douglas fir, common snowberry, forbs
Climatic factors:
Mean annual precipitation—50 to 70 inches
Mean annual air temperature—35 to 42 degrees F
Frost-free period—10 to 50 days

Typical Profile

2 inches to 0—organic mat
0 to 15 inches—black and dark brown very gravelly loamy coarse sand
15 to 29 inches—black extremely gravelly loamy coarse sand
29 to 49 inches—very dark gray and black loamy fine sand
49 to 62 inches—dark brown sandy loam

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Very rapid over moderately rapid
Available water capacity: About 5 inches

Contrasting Inclusions

- Belrick soils on side slopes and ridges
- Linksterly soils on side slopes

Major Use

Woodland

Major Management Limitations

Available water capacity, rock fragments in surface layer, slope, low fertility

General Management Considerations

- Seedlings have a moderate survival rate because of the low available water capacity of the soil.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- The rock fragments in the surface layer restrict the planting of seedlings.

Forest Service Plant Association

CD-S6-13

60E—Haynap very gravelly loamy coarse sand, 30 to 70 percent slopes

Composition

Haynap soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Moraines
Parent material: Ash and scoria
Elevation: 3,500 to 5,200 feet
Native plants: Ponderosa pine, Douglas fir, common snowberry, forbs
Climatic factors:
Mean annual precipitation—50 to 70 inches
Mean annual air temperature—35 to 42 degrees F
Frost-free period—10 to 50 days

Typical Profile

2 inches to 0—organic mat
0 to 15 inches—black and dark brown very gravelly loamy coarse sand
15 to 29 inches—black extremely gravelly loamy coarse sand
29 to 49 inches—very dark gray and black loamy fine sand
49 to 62 inches—dark brown sandy loam

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained

Permeability: Very rapid over moderately rapid
Available water capacity: About 5 inches

Contrasting Inclusions

- Belrick soils on side slopes and ridges
- Linksterly soils on side slopes

Major Use

Woodland

Major Management Limitations

Available water capacity, rock fragments in surface layer, slope, low fertility

General Management Considerations

- Seedlings have a moderate survival rate because of the low available water capacity of the soil.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- The rock fragments in the surface layer restrict the planting of seedlings.

Forest Service Plant Association

CD-S6-13

61C—Henkle-Fryrear-Lava flows complex, 0 to 15 percent slopes

Composition

Henkle soil and similar inclusions—40 percent
Fryrear soil and similar inclusions—35 percent
Lava flows—15 percent
Contrasting inclusions—10 percent

Setting

Landform: Hills
Parent material: Ash
Elevation: 2,800 to 4,000 feet
Native plants: Western juniper, ponderosa pine, mountain big sagebrush, antelope bitterbrush, Idaho fescue, bluebunch wheatgrass
Climatic factors:
Mean annual precipitation—12 to 18 inches
Mean annual air temperature—42 to 47 degrees F
Frost-free period—60 to 90 days

Typical Profile of the Henkle Soil

0.5 inch to 0—organic mat on surface
0 to 17 inches—very dark brown and dark brown very cobbly sandy loam
17 inches—basalt

Properties and Qualities of the Henkle Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Somewhat excessively drained
Permeability: Moderately rapid
Available water capacity: About 1.5 inches

Typical Profile of the Fryrear Soil

0.5 inch to 0—organic mat on surface
0 to 3 inches—dark brown stony sandy loam
3 to 18 inches—dark brown very stony sandy loam
18 to 27 inches—dark yellowish brown very stony sandy loam
27 inches—basalt

Properties and Qualities of the Fryrear Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2.5 inches

Contrasting Inclusions

- Fremkle soils on ridges
- Laidlaw soils in swales
- Wanoga soils on side slopes and ridges

Major Uses

Livestock grazing, woodland

Major Management Limitations

Climate, soil depth, available water capacity, permeability, rock fragments in surface layer, low fertility, susceptibility to compaction, Lava flows

General Management Considerations

Livestock grazing

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Pond development is limited by the soil depth, risk of seepage, and steepness of slope in some areas.
- The restricted depth of the Henkle soil limits the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface.
- The areas of Lava flows limit the areas suitable for grazing and restrict accessibility by livestock.

Woodland

- Seedlings have a poor survival rate because of the low precipitation and low available water capacity.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- The rock fragments on the surface and the areas of Lava flows can interfere with felling, yarding, and other operations involving equipment use.
- Because roots are restricted by the limited depth of the Henkle soil, trees are subject to windthrow.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soils.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- The areas of Lava flows force yarding and skidding paths to converge, which increases the risks of compaction and erosion throughout the unit.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Range Site

Juniper-Pine-Fescue

62D—Henkle-Lava flows-Fryrear complex, 15 to 50 percent slopes

Composition

Henkle soil and similar inclusions—35 percent
Lava flows—30 percent
Fryrear soil and similar inclusions—25 percent
Contrasting inclusions—10 percent

Setting

Landform: Hills
Parent material: Ash
Elevation: 2,800 to 4,000 feet
Native plants: Western juniper, ponderosa pine, mountain big sagebrush, antelope bitterbrush, Idaho fescue, bluebunch wheatgrass
Climatic factors:
  Mean annual precipitation—12 to 18 inches
  Mean annual air temperature—42 to 47 degrees F
  Frost-free period—60 to 90 days

Typical Profile of the Henkle Soil

0.5 inch to 0—organic mat on surface
0 to 17 inches—very dark brown and dark brown very cobbly sandy loam
17 inches—basalt

Properties and Qualities of the Henkle Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Somewhat excessively drained
Permeability: Moderately rapid
Available water capacity: About 1.5 inches

Typical Profile of the Fryrear Soil

0.5 inch to 0—organic mat on surface
0 to 3 inches—dark brown stony sandy loam
3 to 18 inches—dark brown very stony sandy loam
18 to 27 inches—dark yellowish brown very stony sandy loam
27 inches—basalt

Properties and Qualities of the Fryrear Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2.5 inches

Contrasting Inclusions

- Fremkle soils on ridges
- Laidlaw soils in swales
- Wanoga soils on side slopes and ridges

Major Uses

Livestock grazing, woodland

Major Management Limitations

Climate, soil depth, available water capacity, permeability, rock fragments in surface layer, slope, low fertility, susceptibility to compaction, Lava flows

General Management Considerations

Livestock grazing

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Pond development is limited by the soil depth, risk of seepage, and steepness of slope.
- The restricted depth of the Henkle soil limits the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface.
- The areas of Lava flows limit the areas suitable for grazing and restrict accessibility by livestock.
- The steepness of slope restricts livestock distribution and limits range seeding with ground equipment.

Woodland

- Seedlings have a poor survival rate because of the low precipitation and low available water capacity.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- The rock fragments on the surface and the areas of Lava flows can interfere with felling, yarding, and other operations involving equipment use.
- Because roots are restricted by the limited rooting depth of the Henkle soil, trees are subject to windthrow.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soils.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Using machinery only in areas covered with logging slash or brush reduces soil displacement.
- The areas of Lava flows force yarding and skidding paths to converge, which increases the risks of compaction and erosion throughout the unit.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Range Site

Juniper-Pine-Fescue

63C—Holmzie-Searles complex, 0 to 15 percent slopes

Composition

Holmzie soil and similar inclusions—50 percent
Searles soil and similar inclusions—35 percent
Contrasting inclusions—15 percent

Setting

Landform: Hills
Parent material: Ash over residuum
Elevation: 2,500 to 3,500 feet
Native plants: Holmzie soil—western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread; Searles soil—Wyoming big sagebrush, bluebunch wheatgrass, Thurber needlegrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—9 to 11 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—70 to 90 days

Typical Profile of the Holmzie Soil

0 to 7 inches—dark grayish brown loam
7 to 19 inches—brown clay loam
19 to 29 inches—reddish brown gravelly clay
29 inches—weathered tuff

Properties and Qualities of the Holmzie Soil

Depth: Soft bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Slow
Available water capacity: About 5 inches

Typical Profile of the Searles Soil

0 to 7 inches—grayish brown sandy loam
7 to 13 inches—brown loam
13 to 24 inches—brown and yellowish brown very gravelly loam and very gravelly clay loam
24 inches—basalt

Properties and Qualities of the Searles Soil

Depth: Bedrock at a depth of 20 to 40 inches

Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 3 inches

Contrasting Inclusions

- Soils that are on ridges and have bedrock at a depth of 10 to 20 inches
- Soils that are in swales and have a clay or clay loam subsoil over a strongly cemented duripan at a depth of 20 to 40 inches
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Holmzie soil—soil depth, climate
Searles soil—soil depth, climate, surface texture

General Management Considerations

- Care should be taken to protect the Searles soil from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development on these soils is limited by the soil depth and the steepness of slope in some areas.
- The low annual precipitation limits productivity and limits the choice of species for range seeding to drought-tolerant varieties.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Holmzie soil—Pumice Flat 10-12pz
Searles soil—Droughty 8-12pz

64C—Holmzie-Searles complex, moist, 0 to 15 percent slopes

Composition

Holmzie soil and similar inclusions—50 percent
Searles soil and similar inclusions—35 percent
Contrasting inclusions—15 percent

Setting

Landform: Hills
Parent material: Ash over residuum
Elevation: 3,500 to 4,000 feet
Native plants: Ponderosa pine, western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, Ross sedge
Climatic factors:
  Mean annual precipitation—10 to 12 inches
  Mean annual air temperature—47 to 50 degrees F
  Frost-free period—70 to 90 days

Typical Profile of the Holmzie Soil

0 to 7 inches—dark grayish brown loam
7 to 19 inches—brown clay loam
19 to 29 inches—reddish brown gravelly clay
29 inches—weathered tuff

Properties and Qualities of the Holmzie Soil

Depth: Soft bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Slow
Available water capacity: About 5 inches

Typical Profile of the Searles Soil

0 to 7 inches—grayish brown sandy loam
7 to 13 inches—brown loam
13 to 24 inches—brown and yellowish brown very gravelly loam and very gravelly clay loam
24 inches—basalt

Properties and Qualities of the Searles Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 3 inches

Contrasting Inclusions

- Soils that are on ridges and have bedrock at a depth of 10 to 20 inches
- Soils that have a stony or very stony surface layer
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitation

Soil depth

General Management Considerations

- Pond development is limited by the soil depth and the steepness of slope in some areas.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Pine-Juniper-Bitterbrush-Fescue

65A—Houstake sandy loam, 0 to 3 percent slopes

Composition

Houstake soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 2,500 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, and needleandthread
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—70 to 90 days

Typical Profile

0 to 5 inches—brown sandy loam
5 to 22 inches—brown sandy loam
22 to 60 inches—light brownish gray and brown sandy loam

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 7 inches

Contrasting Inclusions

- Stukel soils on ridges
- Redmond and Statz soils in swales
- Rock outcrop

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Surface texture, permeability

General Management Considerations

Irrigated cropland

- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.
- The included areas of Rock outcrop limit the areas suitable for crops and restrict farming operations.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Pumice Flat 10-12pz

66A—Houstake sandy loam, dry, 0 to 3 percent slopes

Composition

Houstake soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 2,500 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, needleandthread, Idaho fescue, and western needlegrass
Climatic factors:
Mean annual precipitation—8 to 10 inches
Mean annual air temperature—49 to 52 degrees F
Frost-free period—80 to 100 days

Typical Profile

0 to 5 inches—brown sandy loam
5 to 22 inches—brown sandy loam
22 to 60 inches—light brownish gray and brown sandy loam

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 7 inches

Contrasting Inclusions

- Stukel soils on ridges
- Redmond and Statz soils in swales
- Rock outcrop

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Surface texture, permeability, climate

General Management Considerations

Irrigated cropland

- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.
- The included areas of Rock outcrop limit the areas suitable for crops and restrict farming operations.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Pumice Flat 8-10pz

67A—Houstake sandy loam, very gravelly substratum, 0 to 3 percent slopes

Composition

Houstake soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 2,500 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, and needleandthread
Climatic factors:
  Mean annual precipitation—10 to 12 inches
  Mean annual air temperature—47 to 50 degrees F
  Frost-free period—70 to 90 days

Typical Profile

0 to 6 inches—brown sandy loam
6 to 22 inches—brown loamy sand
22 to 41 inches—light grayish brown sandy loam
41 to 60 inches—light grayish brown very gravelly sandy loam

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 5 inches

Contrasting Inclusions

- Stukel soils on ridges
- Redmond and Statz soils in swales
- Rock outcrop

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Surface texture, permeability

General Management Considerations

Irrigated cropland

- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.
- The included areas of Rock outcrop limit the areas suitable for crops and restrict farming operations.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Pumice Flat 10-12pz

68A—Iris silt loam, 0 to 1 percent slopes

Composition

Iris soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landscape position: Lake basins
Landform: Lava plains
Parent material: Alluvium derived from loess
Elevation: 2,500 to 3,000 feet
Climatic factors:
  Mean annual precipitation—8 to 11 inches
  Mean annual air temperature—47 to 52 degrees F
  Frost-free period—110 to 140 days

Typical profile

0 to 14 inches—brown silt loam
14 to 34 inches—pale brown silt loam
34 to 60 inches—pale brown silt loam

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 11.5 inches

Contrasting Inclusions

- Agency soils adjacent to basins

Major Use

Irrigated cropland

Major Management Limitation

Surface texture

General Management Considerations

- The silt loam surface layer is subject to compaction from excessive tillage.

69D—Kweo gravelly sandy loam, 8 to 50 percent slopes

Composition

Kweo soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Cinder cones
Parent material: Ash over cinders
Elevation: 3,200 to 5,200 feet
Native plants: Ponderosa pine, Douglas fir, common snowberry, forbs
Climatic factors:
Mean annual precipitation—25 to 35 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—10 to 50 days

Typical Profile

1 inch to 0—organic mat
0 to 13 inches—dark brown gravelly sandy loam
13 to 25 inches—dark reddish brown very gravelly sandy loam
25 to 60 inches—dark yellowish brown cinders

Soil Properties and Qualities

Depth: Cinders at a depth of 20 to 35 inches; bedrock at a depth of 60 inches or more
Drainage class: Excessively drained
Permeability: Moderately rapid over very rapid
Available water capacity: About 3 inches

Contrasting Inclusions

- Soils that are similar to the Kweo soil but have cinders at a depth of more than 35 inches
- Linksterly soils on toe slopes
- Rock outcrop on ridges

Major Use

Woodland

Major Management Limitations

Slope, rooting depth, rock fragments in surface layer, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because this coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Increased erosion, loss of nutrients, and water repellency are likely to result from fires of moderate fireline intensity on south-facing slopes.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CD-S6-13

70D—Kweo-Smiling complex, 8 to 50 percent slopes

Composition

Kweo soil and similar inclusions—60 percent
Smiling soil and similar inclusions—25 percent
Contrasting inclusions—15 percent

Setting

Landform: Kweo soil—cinder cones; Smiling soil—mountains
Parent material: Kweo soil—ash over cinders; Smiling soil—ash over colluvium
Elevation: 3,200 to 4,000 feet
Native plants: Kweo soil—ponderosa pine, Douglas fir, common snowberry, forbs; Smiling soil—ponderosa pine, antelope bitterbrush, greenleaf manzanita, Idaho fescue
Climatic factors:
Mean annual precipitation—25 to 35 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—20 to 50 days

Typical Profile of the Kweo Soil

1 inch to 0—organic mat
0 to 13 inches—dark brown gravelly sandy loam
13 to 25 inches—dark reddish brown very gravelly sandy loam
25 to 60 inches—dark yellowish brown cinders

Properties and Qualities of the Kweo Soil

Depth: Cinders at a depth of 20 to 35 inches; bedrock at a depth of 60 inches or more
Drainage class: Excessively drained
Permeability: Moderately rapid over very rapid
Available water capacity: About 3 inches

Typical Profile of the Smiling Soil

1 inch to 0—organic mat
0 to 16 inches—very dark brown and dark brown sandy loam
16 to 39 inches—dark brown loam
39 to 63 inches—dark brown clay loam

Properties and Qualities of the Smiling Soil

Depth: Colluvium at a depth of 14 to 33 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 10 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 20 to 40 inches
- Bott and Windego soils on side slopes
- Rock outcrop on ridges

Major Use

Woodland

Major Management Limitations

Kweo and Smiling soils—slope, low fertility, susceptibility to compaction
Kweo soil—rooting depth, rock fragments in surface layer

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because the coarse-textured Kweo soil has insufficient anchoring capability, trees are subject to windthrow.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Increased erosion, loss of nutrients, and water repellency may result from fires of moderate fireline intensity on the Kweo soil.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Using machinery only in areas covered with logging slash or brush reduces soil displacement.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

Kweo soil—CD-S6-13
Smiling soil—CP-S2-17

71A—Lafollette sandy loam, 0 to 3 percent slopes

Composition

Lafollette soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Stream terraces
Parent material: Ash over old alluvium
Elevation: 2,500 to 2,800 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, and needleandthread
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—70 to 100 days

Typical Profile

0 to 24 inches—brown sandy loam
24 to 42 inches—pale brown very gravelly sandy loam
42 to 60 inches—dark gray extremely gravelly loamy coarse sand

Soil Properties and Qualities

Depth: Very gravelly substratum at a depth of 20 to 40 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid over very rapid
Available water capacity: About 4 inches

Contrasting Inclusions

- Soils that have weathered tuffaceous rock at a depth of 30 to 60 inches

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Surface texture, permeability

General Management Considerations

Irrigated cropland

- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.

Range Site

Pumice Flat 10-12pz

71B—Lafollette sandy loam, 3 to 8 percent slopes

Composition

Lafollette soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Stream terraces
Parent material: Ash over old alluvium
Elevation: 2,500 to 2,800 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—70 to 100 days

Typical Profile

0 to 24 inches—brown sandy loam
24 to 42 inches—pale brown very gravelly sandy loam
42 to 60 inches—dark gray extremely gravelly loamy coarse sand

Soil Properties and Qualities

Depth: Very gravelly substratum at a depth of 20 to 40 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid over very rapid
Available water capacity: About 4 inches

Contrasting Inclusions

- Soils that have weathered tuffaceous rock at a depth of 30 to 60 inches

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Surface texture, slope, permeability

General Management Considerations

Irrigated cropland

- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.

- Because of the steepness of slope, sprinkler irrigation systems should be used to minimize runoff.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.

Range Site

Pumice Flat 10-12pz

72C—Laidlaw sandy loam, 0 to 15 percent slopes

Composition

Laidlaw soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landscape position: Swales
Landform: Hills
Parent material: Ash over old alluvium
Elevation: 2,800 to 4,000 feet
Native plants: Ponderosa pine, western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, Ross sedge
Climatic factors:
Mean annual precipitation—12 to 18 inches
Mean annual air temperature—42 to 47 degrees F
Frost-free period—60 to 90 days

Typical Profile

0 to 15 inches—dark brown sandy loam
15 to 38 inches—dark yellowish brown sandy loam
38 to 60 inches—dark brown fine sandy loam and loamy fine sand

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 8 inches

Contrasting Inclusions

- Fryrear and Wanoga soils on side slopes
- Rock outcrop

Major Uses

Woodland, livestock grazing

Major Management Limitations

Climate, low fertility, susceptibility to compaction, surface texture, permeability

General Management Considerations

Woodland

- Seedlings have a moderate survival rate because of the low precipitation.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Livestock grazing

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage and the steepness of slope in some areas.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Pine-Juniper-Bitterbrush-Fescue

73C—Lapine gravelly loamy coarse sand, 0 to 15 percent slopes

Composition

Lapine soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landform: Pumice-mantled lava plains
Parent material: Ash and pumice
Elevation: 4,500 to 5,000 feet
Native plants: Ponderosa pine, antelope bitterbrush, needlegrasses
Climatic factors:
Mean annual precipitation—18 to 25 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—20 to 50 days

Typical Profile

1 inch to 0—organic mat
0 to 7 inches—dark brown gravelly loamy coarse sand
7 to 37 inches—very pale brown and light gray extremely gravelly coarse sand and very gravelly loamy coarse sand
37 to 60 inches—light gray gravelly coarse sand

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Excessively drained
Permeability: Very rapid
Available water capacity: About 9 inches

Contrasting Inclusions

- Soils that are moderately well drained or somewhat poorly drained
- Soils that have bedrock at a depth of 40 to 60 inches
- Steiger soils that generally are north of Little River

Major Use

Woodland

Major Management Limitations

Soil depth, soil texture, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because this coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.
- The coarse texture of the soil and the inherent low fertility of the subsoil and substratum restrict root development.

Forest Service Plant Association

CP-S2-12

73D—Lapine gravelly loamy coarse sand, 15 to 30 percent slopes

Composition

Lapine soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landform: Pumice-mantled hills
Parent material: Ash and pumice
Elevation: 4,500 to 5,000 feet
Native plants: Ponderosa pine, antelope bitterbrush, needlegrasses
Climatic factors:
Mean annual precipitation—18 to 25 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—20 to 50 days

Typical Profile

1 inch to 0—organic mat
0 to 7 inches—dark brown gravelly loamy coarse sand
7 to 37 inches—very pale brown and light gray extremely gravelly coarse sand and very gravelly loamy coarse sand
37 to 60 inches—light gray gravelly coarse sand

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Excessively drained
Permeability: Very rapid
Available water capacity: About 9 inches

Contrasting Inclusions

- Soils that are moderately well drained or somewhat poorly drained
- Soils that have bedrock at a depth of 40 to 60 inches
- Steiger soils that generally are north of Little River

Major Use

Woodland

Major Management Limitations

Slope, soil depth, soil texture, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.

- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Wheeled and tracked equipment can be used; however, cable yarding generally is safer and disturbs the soil less.
- Because this coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.
- The coarse texture of the soil and the inherent low fertility of the subsoil and substratum restrict root development.

Forest Service Plant Association

CP-S2-12

73E—Lapine gravelly loamy coarse sand, 30 to 50 percent slopes

Composition

Lapine soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landform: Pumice-mantled hills
Parent material: Ash and pumice
Elevation: 4,500 to 5,000 feet
Native plants: Ponderosa pine, antelope bitterbrush, greenleaf manzanita, Idaho fescue
Climatic factors:
Mean annual precipitation—18 to 25 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—20 to 50 days

Typical Profile

1 inch to 0—organic mat
0 to 7 inches—dark brown gravelly loamy coarse sand
7 to 37 inches—very pale brown and light gray extremely gravelly coarse sand and very gravelly loamy coarse sand
37 to 60 inches—light gray gravelly coarse sand

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Excessively drained
Permeability: Very rapid
Available water capacity: About 9 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 40 to 60 inches
- Steiger soils that generally are north of Little River

Major Use

Woodland

Major Management Limitations

Slope, soil depth, soil texture, low fertility, susceptibility to compaction

General Management Considerations

- Loose soil material moving downslope can cover and damage seedlings.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because this coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Using machinery only in areas covered with logging slash or brush reduces soil displacement.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

- The coarse texture of the soil and the inherent low fertility of the subsoil and substratum restrict root development.

Forest Service Plant Association

CP-S2-17

74C—Lapine gravelly loamy coarse sand, high elevation, 0 to 15 percent slopes

Composition

Lapine soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landform: Pumice-mantled lava plains
Parent material: Ash and pumice
Elevation: 5,000 to 6,000 feet
Native plants: Ponderosa pine, white fir, Douglas fir, snowbrush, chinkapin
Climatic factors:
Mean annual precipitation—18 to 25 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—10 to 40 days

Typical Profile

1 inch to 0—organic mat
0 to 7 inches—dark brown gravelly loamy coarse sand
7 to 37 inches—very pale brown and light gray extremely gravelly coarse sand and very gravelly loamy coarse sand
37 to 60 inches—light gray gravelly coarse sand

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Excessively drained
Permeability: Very rapid
Available water capacity: About 9 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 40 to 60 inches

Major Use

Woodland

Major Management Limitations

Soil depth, soil texture, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because this coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.
- The coarse texture of the soil and the inherent low fertility of the subsoil and substratum restrict root development.

Forest Service Plant Association

CW-H1-11

74D—Lapine gravelly loamy coarse sand, high elevation, 15 to 30 percent slopes

Composition

Lapine soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landform: Pumice-mantled hills
Parent material: Ash and pumice
Elevation: 5,000 to 6,000 feet
Native plants: Ponderosa pine, white fir, Douglas fir, snowbrush, chinkapin
Climatic factors:
Mean annual precipitation—18 to 25 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—10 to 40 days

Typical Profile

1 inch to 0—organic mat
0 to 7 inches—dark brown gravelly loamy coarse sand
7 to 37 inches—very pale brown and light gray extremely gravelly coarse sand and very gravelly loamy coarse sand
37 to 60 inches—light gray gravelly coarse sand

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Excessively drained
Permeability: Very rapid
Available water capacity: About 9 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 40 to 60 inches

Major Use

Woodland

Major Management Limitations

Soil depth, slope, soil texture, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because this coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- Wheeled and tracked equipment can be used; however, cable yarding generally is safer and disturbs the soil less.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.
- The coarse texture of the soil and the inherent low fertility of the subsoil and substratum restrict root development.

Forest Service Plant Association

CW-H1-11

74E—Lapine gravelly loamy coarse sand, high elevation, 30 to 60 percent slopes

Composition

Lapine soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landform: Pumice-mantled hills
Parent material: Ash and pumice
Elevation: 5,000 to 6,000 feet
Native plants: Ponderosa pine, white fir, Douglas fir, snowbrush, and chinkapin
Climatic factors:
Mean annual precipitation—18 to 25 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—10 to 40 days

Typical Profile

1 inch to 0—organic mat
0 to 7 inches—dark brown gravelly loamy coarse sand
7 to 37 inches—very pale brown and light gray extremely gravelly coarse sand and very gravelly loamy coarse sand
37 to 60 inches—light gray gravelly coarse sand

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Excessively drained
Permeability: Very rapid
Available water capacity: About 9 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 40 to 60 inches

Major Use

Woodland

Major Management Limitations

Soil depth, slope, soil texture, low fertility, susceptibility to compaction

General Management Considerations

- Loose soil material moving downslope can cover and damage seedlings.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because this coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or

crowning road surfaces; using sediment traps; and undulating road grades.

- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Using machinery only in areas covered with logging slash or brush reduces soil displacement.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.
- The coarse texture of the soil and the inherent low fertility of the subsoil and substratum restrict root development.

Forest Service Plant Association

CW-H1-11

75A—Lapine gravelly loamy coarse sand, low, 0 to 3 percent slopes

Composition

Lapine soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landscape position: Depressions
Landform: Pumice-mantled lava plains
Parent material: Ash and pumice
Elevation: 4,200 to 4,500 feet
Native plants: Lodgepole pine, antelope bitterbrush, sedges
Climatic factors:
Mean annual precipitation—18 to 25 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—10 to 30 days

Typical Profile

1 inch to 0—organic mat
0 to 7 inches—dark brown gravelly loamy coarse sand
7 to 37 inches—very pale brown and light gray extremely gravelly coarse sand and very gravelly loamy coarse sand
37 to 60 inches—light gray gravelly coarse sand

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Excessively drained
Permeability: Very rapid
Available water capacity: About 9 inches

Contrasting Inclusions

- Soils that are moderately well drained or somewhat poorly drained

Major Use

Woodland

Major Management Limitations

Frost hazard, soil depth, soil texture, low fertility, susceptibility to compaction

General Management Considerations

- Severe frost or frost heaving can damage or kill seedlings.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because this coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.
- The coarse texture of the soil and the inherent low fertility of the subsoil and substratum restrict root development.

Forest Service Plant Association

CL-S2-12

76F—Lapine-Rock outcrop complex, high elevation, 50 to 70 percent slopes

Composition

Lapine soil and similar inclusions—75 percent
Rock outcrop—15 percent
Contrasting inclusions—10 percent

Setting

Landform: Pumice plains
Parent material: Volcanic ash and pumice
Elevation: 5,000 to 6,000 feet

Native plants: Ponderosa pine, white fir, Douglas fir, snowbrush, chinkapin
Climatic factors:
Mean annual precipitation—18 to 25 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—10 to 40 days

Typical Profile

1 inch to 0—organic mat
0 to 7 inches—dark brown gravelly loamy coarse sand
7 to 37 inches—very pale brown and light gray extremely gravelly coarse sand and very gravelly loamy coarse sand
37 to 60 inches—light gray gravelly coarse sand

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Excessively drained
Permeability: Very rapid
Available water capacity: About 9 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 40 to 60 inches

Major Use

Woodland

Major Management Limitations

Rock outcrop, soil depth, slope, soil texture, low fertility, susceptibility to compaction

General Management Considerations

- Loose soil material moving downslope can cover and damage seedlings.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because this coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.
- The coarse texture of the soil and the inherent low fertility of the subsoil and substratum restrict root development.

Forest Service Plant Association

CW-H1-11

77—Lava flows

Composition

Lava flows—85 percent
Contrasting inclusions—15 percent

Setting

Slope: 0 to 50 percent
Elevation: 3,200 to 5,200 feet
Climatic factors:
Mean annual precipitation—30 to 50 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—20 to 50 days

Description of Lava flows

Lateral hardened rock consisting of cooled molten lava

Contrasting Inclusions

- Soils that have bedrock at a depth of 1 inch to 20 inches

Major Use

Wildlife habitat

78C—Lickskillet-Deschutes complex, 0 to 15 percent slopes

Composition

Lickskillet soil and similar inclusions—45 percent
Deschutes soil and similar inclusions—40 percent
Contrasting inclusions—15 percent

Setting

Landform: Lickskillet soil—hills; Deschutes soil—lava plains
Parent material: Lickskillet soil—colluvium; Deschutes soil—ash

Elevation: 2,500 to 3,500 feet
Native plants: Lickskillet soil—Wyoming big sagebrush, bluebunch wheatgrass, Thurber needlegrass, Sandberg bluegrass; Deschutes soil—western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—70 to 90 days

Typical Profile of the Lickskillet Soil

0 to 7 inches—dark brown very stony sandy loam
7 to 14 inches—dark brown very cobbly sandy loam
14 inches—tuff

Properties and Qualities of the Lickskillet Soil

Depth: Bedrock at a depth of 12 to 20 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 1 inch

Typical Profile of the Deschutes Soil

0 to 17 inches—grayish brown sandy loam
17 to 31 inches—light grayish brown sandy loam
31 inches—basalt

Properties and Qualities of the Deschutes Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 4 inches

Contrasting Inclusions

- Houstake soils in swales

Major Use

Livestock grazing

Major Management Limitations

Surface texture, soil depth, rock fragments in surface layer

General Management Considerations

- Care should be taken to protect these soils from wind erosion when applying range improvement practices.
- Because the Deschutes soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and the steepness of slope in some areas.
- The restricted depth of the Lickskillet soil limits the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface.

Range Site

Lickskillet soil—Droughty 8-12pz
Deschutes soil—Pumice Flat 10-12pz

79C—Lickskillet-Redcliff very gravelly loams, 0 to 15 percent slopes

Composition

Lickskillet soil and similar inclusions—45 percent
Redcliff soil and similar inclusions—40 percent
Contrasting inclusions—15 percent

Setting

Landscape position: Lickskillet soil—knobs and ridges; Redcliff soil—side slopes
Landform: Hills
Parent material: Colluvium
Elevation: 2,600 to 4,500 feet
Native plants: Wyoming big sagebrush, bluebunch wheatgrass, Thurber needlegrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—110 to 140 days

Typical Profile of the Lickskillet Soil

0 to 9 inches—dark grayish brown very gravelly loam
9 to 13 inches—brown extremely gravelly loam
13 inches—fractured rhyolite

Properties and Qualities of the Lickskillet Soil

Depth: Bedrock at a depth of 12 to 20 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 1 inch

Typical Profile of the Redcliff Soil

0 to 19 inches—brown very gravelly loam
19 to 25 inches—dark yellowish brown extremely gravelly clay loam
25 inches—fractured rhyolite

Properties and Qualities of the Redcliff Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 2 inches

Contrasting Inclusions

- Madras and Agency soils on toe slopes
- Era soils on north aspects

Major Use

Livestock grazing

Major Management Limitations

Soil depth, permeability

General Management Considerations

- Pond development is limited by the soil depth, the risk of seepage, and the steepness of slope in some areas.
- The restricted depth of the Lickskillet soil limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Droughty 8-12pz

80D—Lickskillet-Redcliff very gravelly loams, 15 to 30 percent south slopes

Composition

Lickskillet soil and similar inclusions—45 percent
Redcliff soil and similar inclusions—40 percent
Contrasting inclusions—15 percent

Setting

Landscape position: Lickskillet soil—knobs and ridges; Redcliff soil—side slopes
Landform: Hills
Parent material: Colluvium
Elevation: 2,600 to 4,500 feet
Native plants: Western juniper, Wyoming big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—110 to 140 days

Typical Profile of the Lickskillet Soil

0 to 9 inches—dark grayish brown very gravelly loam
9 to 13 inches—brown extremely gravelly loam
13 inches—fractured rhyolite

Properties and Qualities of the Lickskillet Soil

Depth: Bedrock at a depth of 12 to 20 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 1 inch

Typical Profile of the Redcliff Soil

0 to 19 inches—brown very gravelly loam
19 to 25 inches—dark yellowish brown extremely gravelly clay loam
25 inches—fractured rhyolite

Properties and Qualities of the Redcliff Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 2 inches

Contrasting Inclusions

- Simas soils that are on side slopes and ridges and support low sagebrush
- Era soils in swales
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Soil depth, permeability, slope

General Management Considerations

- Pond development is limited by the soil depth, risk of seepage, and steepness of slope.
- The restricted depth of the Lickskillet soil limits the choice of species for range seeding to drought-tolerant varieties.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

South 9-12pz

80E—Lickskillet-Redcliff very gravelly loams, 30 to 60 percent south slopes

Composition

Lickskillet soil and similar inclusions—45 percent
Redcliff soil and similar inclusions—40 percent
Contrasting inclusions—15 percent

Setting

Landscape position: Lickskillet soil—knobs and ridges; Redcliff soil—side slopes
Landform: Hills
Parent material: Colluvium
Elevation: 2,600 to 4,500 feet
Native plants: Western juniper, Wyoming big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—110 to 140 days

Typical Profile of the Lickskillet Soil

0 to 9 inches—dark grayish brown very gravelly loam
9 to 13 inches—brown extremely gravelly loam
13 inches—fractured rhyolite

Properties and Qualities of the Lickskillet Soil

Depth: Bedrock at a depth of 12 to 20 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 1 inch

Typical Profile of the Redcliff Soil

0 to 19 inches—brown very gravelly loam
19 to 25 inches—dark yellowish brown extremely gravelly clay loam
25 inches—fractured rhyolite

Properties and Qualities of the Redcliff Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 2 inches

Contrasting Inclusions

- Simas soils that are on side slopes and ridges and support low sagebrush
- Era soils in swales
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Soil depth, permeability, slope

General Management Considerations

- Pond development is limited by the soil depth, risk of seepage, and steepness of slope.
- The restricted depth of the Lickskillet soil limits the choice of species for range seeding to drought-tolerant varieties.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.
- The steepness of slope restricts livestock distribution and limits range seeding with ground equipment.
- The steep, south-facing slopes are less suited to grazing in hot periods during the grazing season.

Range Site

South 9-12pz

81F—Lickskillet-Rock outcrop complex, 45 to 80 percent slopes

Composition

Lickskillet soil and similar inclusions—60 percent
Rock outcrop—35 percent
Contrasting inclusions—5 percent

Setting

Position on landscape: South-facing side slopes
Landform: Canyonsides
Parent material: Colluvium
Elevation: 2,000 to 4,500 feet
Native plants: Western juniper, Wyoming big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—8 to 10 inches
Mean annual air temperature—49 to 52 degrees F
Frost-free period—70 to 100 days

Typical Profile of the Lickskillet Soil

0 to 7 inches—dark brown very stony sandy loam
7 to 14 inches—dark brown very cobbly sandy loam
14 inches—tuff

Properties and Qualities of the Lickskillet Soil

Depth: Bedrock at a depth of 12 to 20 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 1 inch

Contrasting Inclusions

- Deep soils that are sandy throughout

Major Use

Livestock grazing

Major Management Limitations

Rock outcrop, soil depth, climate, surface stones, slope

General Management Considerations

- The low annual precipitation and restricted soil depth limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- The areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.
- The steepness of slope, areas of Rock outcrop, and stones on the surface restrict livestock distribution and restrict range seeding with ground equipment.
- The steep, south-facing slopes are less suited to grazing in hot periods during the grazing season.

Range Site

South 9-12pz

82C—Linksterly sandy loam, 0 to 15 percent slopes

Composition

Linksterly soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Moraines
Parent material: Ash over glacial till
Elevation: 3,700 to 4,400 feet
Native plants: Ponderosa pine, Douglas fir, common snowberry, forbs
Climatic factors:
Mean annual precipitation—50 to 60 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—20 to 50 days

Typical Profile

3 inches to 0—organic mat
0 to 14 inches—very dark grayish brown sandy loam
14 to 41 inches—black and very dark grayish brown loamy fine sand
41 to 60 inches—dark reddish brown very cobbly sandy loam

Soil Properties and Qualities

Depth: Glacial till at a depth of 40 to 60 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 7 inches

Contrasting Inclusions

- Belrick soils on side slopes and ridges
- Douthit soils on ridges
- Haynap soils that are south of Round Lake and are on side slopes

Major Use

Woodland

Major Management Limitations

Low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CD-S6-13

82D—Linksterly sandy loam, 15 to 30 percent slopes

Composition

Linksterly soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Moraines
Parent material: Ash over glacial till
Elevation: 3,700 to 4,400 feet
Native plants: Ponderosa pine, Douglas fir, common snowberry, and forbs
Climatic factors:
Mean annual precipitation—50 to 60 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—20 to 50 days

Typical Profile

3 inches to 0—organic mat
0 to 14 inches—very dark grayish brown sandy loam
14 to 41 inches—black and very dark grayish brown loamy fine sand
41 to 60 inches—dark reddish brown very cobbly sandy loam

Soil Properties and Qualities

Depth: Glacial till at a depth of 40 to 60 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 7 inches

Contrasting Inclusions

- Belrick soils on side slopes and ridges
- Douthit soils on ridges
- Haynap soils that are south of Round Lake and are on side slopes

Major Use

Woodland

Major Management Limitations

Slope, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Wheeled and tracked equipment can be used; however, cable yarding generally is safer and disturbs the soil less.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CD-S6-13

82E—Linksterly sandy loam, 30 to 50 percent slopes

Composition

Linksterly soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Moraines
Parent material: Ash over glacial till
Elevation: 3,700 to 4,400 feet
Native plants: Ponderosa pine, Douglas fir, common snowberry, forbs
Climatic factors:
Mean annual precipitation—50 to 60 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—20 to 50 days

Typical Profile

3 inches to 0—organic mat
0 to 14 inches—very dark grayish brown sandy loam
14 to 41 inches—black and very dark grayish brown loamy fine sand
41 to 60 inches—dark reddish brown very cobbly sandy loam

Soil Properties and Qualities

Depth: Glacial till at a depth of 40 to 60 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 7 inches

Contrasting Inclusions

- Belrick soils on side slopes and ridges
- Douthit soils on ridges
- Haynap soils that are south of Round Lake and are on side slopes

Major Use

Woodland

Major Management Limitations

Slope, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using

sediment traps; and undulating road grades.

- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Using machinery only in areas covered with logging slash or brush reduces soil displacement.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CD-S6-13

83C—Linksterly sandy loam, cool, 0 to 15 percent slopes

Composition

Linksterly soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Moraines
Parent material: Ash over glacial till
Elevation: 4,400 to 5,200 feet
Native plants: Lodgepole pine, beargrass
Climatic factors:
Mean annual precipitation—60 to 70 inches
Mean annual air temperature—35 to 42 degrees F
Frost-free period—10 to 30 days

Typical Profile

3 inches to 0—organic mat
0 to 14 inches—very dark grayish brown sandy loam
14 to 41 inches—black and very dark grayish brown loamy fine sand
41 to 60 inches—dark reddish brown very cobbly sandy loam

Soil Properties and Qualities

Depth: Glacial till at a depth of 40 to 60 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 7 inches

Contrasting Inclusions

- Belrick soils on side slopes and ridges
- Douthit soils on ridges
- Rock outcrop on ridges

Major Use

Woodland

Major Management Limitations

Frost hazard, low fertility, susceptibility to compaction

General Management Considerations

- Severe frost or frost heaving can damage or kill seedlings.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CL-M4-11

83D—Linksterly sandy loam, cool, 15 to 30 percent slopes

Composition

Linksterly soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Moraines
Parent material: Ash over glacial till
Elevation: 4,400 to 5,200 feet
Native plants: Lodgepole pine and beargrass
Climatic factors:
Mean annual precipitation—60 to 70 inches
Mean annual air temperature—35 to 42 degrees F
Frost-free period—10 to 30 days

Typical Profile

3 inches to 0—organic mat
0 to 14 inches—very dark grayish brown sandy loam
14 to 41 inches—black and very dark grayish brown loamy fine sand
41 to 60 inches—dark reddish brown very cobbly sandy loam

Soil Properties and Qualities

Depth: Glacial till at a depth of 40 to 60 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 7 inches

Contrasting Inclusions

- Belrick soils on side slopes and ridges
- Douthit soils on ridges
- Rock outcrop on ridges

Major Use

Woodland

Major Management Limitations

Frost hazard, slope, low fertility, susceptibility to compaction

General Management Considerations

- Severe frost or frost heaving can damage or kill seedlings.
- Wheeled and tracked equipment can be used; however, cable yarding generally is safer and disturbs the soil less.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CL-M4-11

84C—Linksterly-Blowout complex, 0 to 15 percent slopes

Composition

Linksterly soil and similar inclusions—65 percent
Blowout—20 percent
Contrasting inclusions—15 percent

Setting

Landform: Moraines
Parent material: Ash over glacial till
Elevation: 4,400 to 5,200 feet
Native plants: Lodgepole pine, beargrass
Climatic factors:
Mean annual precipitation—60 to 70 inches
Mean annual air temperature—35 to 40 degrees F
Frost-free period—10 to 30 days

Typical Profile of the Linksterly Soil

3 inches to 0—organic mat
0 to 14 inches—very dark grayish brown sandy loam
14 to 41 inches—black and very dark grayish brown loamy fine sand
41 to 60 inches—dark reddish brown very cobbly sandy loam

Properties and Qualities of the Linksterly Soil

Depth: Glacial till at a depth of 40 to 60 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 7 inches

Description of Blowout

Nonvegetated depressions where the soil material has been removed by wind

Contrasting Inclusions

- Belrick soils on ridges
- Haynap soils that are north and east of Blue Lake

Major Use

Woodland

Major Management Limitations

Low fertility, susceptibility to compaction, wind erosion

General Management Considerations

- This unit is susceptible to wind erosion if the vegetation is removed.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CL-M4-11

85A—Lundgren sandy loam, 0 to 3 percent slopes

Composition

Lundgren soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landform: Outwash plains
Parent material: Ash over glacial outwash
Elevation: 2,800 to 4,000 feet

Native plants: Ponderosa pine, antelope bitterbrush, wax currant, Idaho fescue, western needlegrass
Climatic factors:
Mean annual precipitation—12 to 18 inches
Mean annual air temperature—42 to 47 degrees F
Frost-free period—60 to 90 days

Typical Profile

0 to 14 inches—very dark grayish brown sandy loam
14 to 23 inches—dark brown gravelly sandy loam
23 to 38 inches—dark brown very gravelly loam
38 to 60 inches—brown extremely gravelly sandy loam

Soil Properties and Qualities

Depth: Glacial outwash at a depth of 20 to 40 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 5 inches

Contrasting Inclusions

- Omahaling soils on flood plains

Major Uses

Woodland, livestock grazing

Major Management Limitations

Climate, low fertility, susceptibility to compaction, surface texture, permeability

General Management Considerations

Woodland

- Seedlings have a moderate survival rate because of the low precipitation.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Livestock grazing

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.

Range Site

Pine-Bitterbrush-Fescue

86A—Madras sandy loam, 0 to 3 percent slopes

Composition

Madras soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Loess over semiconsolidated sediment
Elevation: 2,000 to 3,000 feet
Native plants: Western juniper, basin big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
Mean annual precipitation—8 to 10 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—120 to 140 days

Typical Profile

0 to 10 inches—brown sandy loam
10 to 23 inches—yellowish brown loam and clay loam
23 to 27 inches—semiconsolidated sediment consisting of gravel, cobbles, and sand of the Deschutes Formation
27 inches—basalt of the Deschutes Formation

Soil Properties and Qualities

Depth: Bedrock at a depth of 22 to 40 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 3.5 inches

Contrasting Inclusions

- Era soils in swales
- Cullius soils on lava plains
- Caphealy and Reuter soils on hills

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Soil depth, surface texture, permeability, climate

General Management Considerations

Irrigated cropland

- Well-managed irrigation systems are needed for deep-rooted crops such as alfalfa.

- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.
- Because water soluble chemicals may be carried in the runoff, care should be taken to prevent excessive irrigation rates that may result in overland flow.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Droughty Loam 8-10pz

86B—Madras sandy loam, 3 to 8 percent slopes

Composition

Madras soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Loess over semiconsolidated sediment
Elevation: 2,000 to 3,000 feet
Native plants: Western juniper, basin big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
Mean annual precipitation—8 to 10 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—120 to 140 days

Typical Profile

0 to 10 inches—brown sandy loam
10 to 23 inches—yellowish brown loam and clay loam
23 to 27 inches—semiconsolidated sediment consisting of gravel, cobbles, and sand of the Deschutes Formation
27 inches—basalt of the Deschutes Formation

Soil Properties and Qualities

Depth: Bedrock at a depth of 22 to 40 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 3.5 inches

Contrasting Inclusions

- Era soils in swales
- Cullius soils on lava plains
- Caphealy and Reuter soils on hills

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Soil depth, surface texture, permeability, slope, climate

General Management Considerations

Irrigated cropland

- Well-managed irrigation systems are needed for deep-rooted crops such as alfalfa.
- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.
- Because water soluble chemicals may be carried in the runoff, care should be taken to prevent excessive irrigation rates that may lead to overland flow.
- Because of the steepness of slope, sprinkler irrigation systems should be used to minimize runoff.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Droughty Loam 8-10pz

87A—Madras loam, 0 to 3 percent slopes

Composition

Madras soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Loess over semiconsolidated sediment
Elevation: 2,000 to 3,000 feet
Native plants: Western juniper, basin big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:

Mean annual precipitation—8 to 10 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—120 to 140 days

Typical Profile

0 to 10 inches—brown loam
10 to 23 inches—yellowish brown loam and clay loam
23 to 27 inches—semiconsolidated sediment consisting of gravel, cobbles, and sand of the Deschutes Formation
27 inches—basalt of the Deschutes Formation

Soil Properties and Qualities

Depth: Bedrock at a depth of 22 to 40 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 4 inches

Contrasting Inclusions

- Era soils in swales
- Cullius soils on lava plains
- Soils that have a silt loam surface layer

Major Uses

Irrigated cropland (fig. 7), livestock grazing

Figure 7.—Area of Madras loam, 0 to 3 percent slopes, used for production of grass seed. Mt. Jefferson is in background.

Major Management Limitations

Permeability, climate, soil depth

General Management Considerations

Irrigated cropland

- Because water soluble chemicals may be carried in the runoff, care should be taken to prevent excessive irrigation rates that may lead to overland flow.

Livestock grazing

- Pond development is limited by the soil depth.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Droughty Loam 8-10pz

87B—Madras loam, 3 to 8 percent slopes

Composition

Madras soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Loess over semiconsolidated sediment
Elevation: 2,000 to 3,000 feet
Native plants: Western juniper, basin big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
Mean annual precipitation—8 to 10 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—120 to 140 days

Typical Profile

0 to 10 inches—brown loam
10 to 23 inches—yellowish brown loam and clay loam
23 to 27 inches—semiconsolidated sediment consisting of gravel, cobbles, and sand of the Deschutes Formation
27 inches—basalt of the Deschutes Formation

Soil Properties and Qualities

Depth: Bedrock at a depth of 22 to 40 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 4 inches

Contrasting Inclusions

- Era soils in swales
- Cullius soils on lava plains
- Soils that have a silt loam surface layer

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Permeability, slope, climate, soil depth

General Management Considerations

Irrigated cropland

- Because water soluble chemicals may be carried in the runoff, care should be taken to prevent excessive irrigation rates that may lead to overland flow.
- Because of the steepness of slope, sprinkler irrigation systems should be used to minimize runoff.

Livestock grazing

- Pond development is limited by the soil depth.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Droughty Loam 8-10pz

87C—Madras loam, 8 to 15 percent slopes

Composition

Madras soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Loess over semiconsolidated sediment
Elevation: 2,000 to 3,000 feet
Native plants: Western juniper, basin big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
Mean annual precipitation—8 to 10 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—120 to 140 days

Typical Profile

0 to 10 inches—brown loam
10 to 23 inches—yellowish brown loam and clay loam
23 to 27 inches—semiconsolidated sediment consisting of gravel, cobbles, and sand of the Deschutes Formation
27 inches—basalt of the Deschutes Formation

Soil Properties and Qualities

Depth: Bedrock at a depth of 22 to 40 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 4 inches

Contrasting Inclusions

- Era soils in swales
- Cullius soils on lava plains
- Soils that have a silt loam surface layer

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Permeability, slope, climate, soil depth

General Management Considerations

Irrigated cropland

- Because water soluble chemicals may be carried in the runoff, care should be taken to prevent excessive irrigation rates that may lead to overland flow.
- Because of the steepness of slope, sprinkler irrigation systems should be used to minimize runoff.

Livestock grazing

- Pond development is limited by the soil depth.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Droughty Loam 8-10pz

88D—Menbo stony loam, 5 to 25 percent slopes

Composition

Menbo soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Hills
Parent material: Colluvium derived from basalt and welded tuff with ash on the surface
Elevation: 4,400 to 5,500 feet
Native plants: Mountain big sagebrush, antelope bitterbrush, Idaho fescue, bluebunch wheatgrass, Thurber needlegrass

Climatic factors:

Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 3 inches—grayish brown stony loam
3 to 8 inches—dark grayish brown gravelly loam
8 to 26 inches—brown very cobbly clay loam
26 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Slow
Available water capacity: About 5 inches

Contrasting Inclusions

- Ninemile soils on lava plains and toe slopes
- Westbutte soils on steep hillsides
- Rock outcrop on knolls

Major Use

Livestock grazing

Major Management Limitations

Climate, soil depth, rock fragments

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Pond development is limited by the soil depth and by the steepness of slope in some areas.
- Range seeding with ground equipment is limited by the rock fragments on the surface.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Stony Loam 10-12pz

89A—Milcan gravelly sandy loam, 0 to 5 percent slopes

Composition

Milcan soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landscape position: Basins
Landform: Lava plains
Parent material: Ash over old alluvium
Elevation: 4,300 to 4,800 feet
Native plants: Mountain big sagebrush, Idaho fescue, Thurber needlegrass, western needlegrass
Climatic factors:

Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 8 inches—grayish brown gravelly sandy loam
8 to 17 inches—brown loamy sand
17 to 38 inches—pale brown sandy loam
38 to 60 inches—indurated duripan

Soil Properties and Qualities

Depth: Duripan at a depth of 20 to 40 inches; bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Moderately slow
Available water capacity: About 6 inches

Contrasting Inclusions

- Stookmoor soils on terraces
- Borobey soils along drainageways

Major Use

Livestock grazing

Major Management Limitations

Climate, surface texture, soil depth, permeability

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and risk of seepage.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Pumice 8-10pz

90C—Minkwell sandy loam, 0 to 15 percent slopes

Composition

Minkwell soil and similar inclusions—85 percent

Contrasting inclusions—15 percent

Setting

Landform: Moraines
Parent material: Ash over glacial till
Elevation: 3,700 to 5,000 feet
Native plants: Ponderosa pine, Douglas fir, snowbrush, greenleaf manzanita
Climatic factors:
Mean annual precipitation—50 to 70 inches
Mean annual air temperature—35 to 44 degrees F
Frost-free period—10 to 50 days

Typical Profile

1 inch to 0—organic mat
0 to 23 inches—dark brown sandy loam
23 to 34 inches—dark reddish brown cobbly loam
34 to 60 inches—dark reddish brown and dark brown cobbly clay loam

Soil Properties and Qualities

Depth: Glacial till at a depth of 20 to 30 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 8 inches

Contrasting Inclusions

- Bott and Douthit soils on ridges

Major Use

Woodland

Major Management Limitations

Low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

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CW-S1-12

90D—Minkwell sandy loam, 15 to 30 percent slopes

Composition

Minkwell soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Moraines
Parent material: Ash over glacial till
Elevation: 3,700 to 5,000 feet
Native plants: Ponderosa pine, Douglas fir, snowbrush, greenleaf manzanita
Climatic factors:
Mean annual precipitation—50 to 70 inches
Mean annual air temperature—35 to 44 degrees F
Frost-free period—10 to 50 days

Typical Profile

1 inch to 0—organic mat
0 to 23 inches—dark brown sandy loam
23 to 34 inches—dark reddish brown cobbly loam
34 to 60 inches—dark reddish brown and dark brown cobbly clay loam

Soil Properties and Qualities

Depth: Glacial till at a depth of 20 to 30 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 8 inches

Contrasting Inclusions

- Bott and Douthit soils on ridges

Major Use

Woodland

Major Management Limitations

Slope, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Wheeled and tracked equipment can be used;

however, cable yarding generally is safer and disturbs the soil less.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

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CW-S1-12

90E—Minkwell sandy loam, 30 to 50 percent slopes

Composition

Minkwell soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Moraines
Parent material: Ash over glacial till
Elevation: 3,700 to 5,000 feet
Native plants: Ponderosa pine, Douglas fir, snowbrush, and greenleaf manzanita
Climatic factors:
Mean annual precipitation—50 to 70 inches
Mean annual air temperature—35 to 44 degrees F
Frost-free period—10 to 50 days

Typical Profile

1 inch to 0—organic mat
0 to 23 inches—dark brown sandy loam
23 to 34 inches—dark reddish brown very cobbly loam
34 to 60 inches—dark reddish brown and dark brown cobbly clay loam

Soil Properties and Qualities

Depth: Glacial till at a depth of 20 to 30 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 8 inches

Contrasting Inclusions

- Bott and Douthit soils on ridges

Major Use

Woodland

Major Management Limitations

Slope, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Using machinery only in areas covered with logging slash or brush reduces soil displacement.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

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CW-S1-12

91B—Ninemile sandy loam, 0 to 10 percent slopes

Composition

Ninemile soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Residuum derived from basalt with ash on the surface
Elevation: 4,200 to 4,800 feet
Native plants: Low sagebrush, Idaho fescue, Thurber needlegrass, western needlegrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 7 inches—grayish brown sandy loam
7 to 19 inches—pale brown clay and gravelly clay
19 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Very slow
Available water capacity: About 3 inches

Contrasting Inclusions

- Very shallow soils that have a very stony surface layer and are along bedrock escarpments
- Embal and Dester soils along drainageways
- Choptie soils on hills

Major Use

Livestock grazing

Major Management Limitations

Climate, surface texture, soil depth

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth.

Range Site

Pumice Claypan 9-11pz

92B—Ninemile very cobbly loam, 0 to 10 percent slopes

Composition

Ninemile soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Residuum derived from basalt
Elevation: 4,200 to 5,500 feet
Native plants: Low sagebrush, Idaho fescue, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—12 to 14 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 7 inches—grayish brown very cobbly loam
7 to 19 inches—pale brown clay and gravelly clay
19 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Very slow
Available water capacity: About 3 inches

Contrasting Inclusions

- Very shallow soils that have a very stony surface layer and are along bedrock escarpments
- Embal and Dester soils along drainageways
- Choptie soils on hills
- Reluctan soils on lava plains

Major Use

Livestock grazing

Major Management Limitations

Climate, soil depth, rock fragments in surface layer

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Pond development is limited by the soil depth.
- Range seeding with ground equipment is limited by the rock fragments on the surface.

Range Site

Claypan 12-16pz

93B—Ninemile-Dester complex, 1 to 8 percent slopes

Composition

Ninemile soil and similar inclusions—50 percent
Dester soil and similar inclusions—35 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ninemile soil—residuum with ash on the surface; Dester soil—ash over residuum
Elevation: 4,200 to 4,500 feet
Native plants: Ninemile soil—low sagebrush, Idaho fescue, Thurber needlegrass, western needlegrass; Dester soil—mountain big sagebrush, Idaho fescue, Thurber needlegrass, western needlegrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile of the Ninemile Soil

0 to 7 inches—grayish brown sandy loam
7 to 19 inches—pale brown clay and gravelly clay
19 inches—basalt

Properties and Qualities of the Ninemile Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Very slow
Available water capacity: About 3 inches

Typical Profile of the Dester Soil

0 to 17 inches—grayish brown sandy loam
17 to 24 inches—brown clay loam
24 to 34 inches—light yellowish brown gravelly clay loam
34 inches—basalt

Properties and Qualities of the Dester Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 5 inches

Contrasting Inclusions

- Soils that have a stony surface layer and are along bedrock escarpments
- Borobey soils along drainageways
- Choptie soils on hills

Major Use

Livestock grazing

Major Management Limitations

Climate, surface texture, soil depth

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth.

Range Site

Ninemile soil—Pumice Claypan 9-11pz
Dester soil—Pumice 8-10pz

94A—Omahaling fine sandy loam, 0 to 5 percent slopes

Composition

Omahaling soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Flood plains (fig. 8)

Figure 8.—Typical area of Omahaling fine sandy loam, 0 to 5 percent slopes. Three Sisters Mountains in background.

Parent material: Ash over old alluvium
Elevation: 2,800 to 4,000 feet
Native plants: Quaking aspen, willow, sedges
Climatic factors:
  Mean annual precipitation—12 to 18 inches
  Mean annual air temperature—42 to 47 degrees F
  Frost-free period—60 to 90 days

Typical Profile

0 to 19 inches—dark grayish brown fine sandy loam
19 to 23 inches—grayish brown silt loam
23 to 29 inches—dark gray gravelly sand
29 to 48 inches—dark grayish brown silt loam
48 to 60 inches—dark gray extremely gravelly coarse sand

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Somewhat poorly drained

Depth to water table: 24 to 36 inches below the surface in April through June
Permeability: Moderate over very rapid
Available water capacity: About 8 inches

Contrasting Inclusions

- Soils that are poorly drained
- Soils that have a loam surface layer and a gravelly clay loam subsoil
- Soils that have slopes of more than 5 percent
- Gravel deposits

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Permeability, slope, high water table, climate

General Management Considerations

Irrigated cropland

- Applied fertilizers and chemicals may be leached and ground water may be contaminated because of the very rapid permeability of the substratum.
- Care should be taken when using flood irrigation on slopes of more than 3 percent.

Livestock grazing

- If seeding is needed, select plants that tolerate seasonal wetness.
- Grazing during wet periods can cause soil compaction and displacement and damage plants.
- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Pond development is limited by the risk of seepage.

Range Site

Wet Meadow

95E—Parrego-Rock outcrop-Windego complex, 30 to 50 percent slopes

Composition

Parrego soil and similar inclusions—35 percent
Rock outcrop—25 percent
Windego soil and similar inclusions—25 percent
Contrasting inclusions—15 percent

Setting

Landform: Mountains
Parent material: Ash over colluvium and residuum
Elevation: 3,000 to 4,000 feet
Native plants: Ponderosa pine, antelope bitterbrush, greenleaf manzanita, needlegrasses
Climatic factors:
Mean annual precipitation—20 to 40 inches
Mean annual air temperature—40 to 47 degrees F
Frost-free period—50 to 90 days

Typical Profile of the Parrego Soil

3 inches to 0—organic mat
0 to 5 inches—dark brown sandy loam
5 to 13 inches—brown loam
13 to 24 inches—brown clay loam
24 inches—weathered tuff

Properties and Qualities of the Parrego Soil

Depth: Colluvium at a depth of 4 to 7 inches; soft bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 4 inches

Typical Profile of the Windego Soil

1 inch to 0—organic mat
0 to 19 inches—dark brown and brown sandy loam
19 to 30 inches—brown very cobbly loam
30 to 60 inches—brown and yellowish brown very cobbly clay loam

Properties and Qualities of the Windego Soil

Depth: Colluvium at a depth of 14 to 25 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 6 inches

Contrasting Inclusions

- Smiling soils on side slopes
- Thorn soils on ridges

Major Use

Woodland

Major Management Limitations

Rock outcrop, climate, slope, low fertility, susceptibility to compaction

General Management Considerations

- Seedlings have a moderate survival rate because of the low precipitation.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less

damaging to the soil surface.

- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Using machinery only in areas covered with logging slash or brush reduces soil displacement.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

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CP-S2-13

96D—Parrego-Thorn-Rock outcrop complex, 15 to 50 percent slopes

Composition

Parrego soil and similar inclusions—35 percent
Thorn soil and similar inclusions—25 percent
Rock outcrop—25 percent
Contrasting inclusions—15 percent

Setting

Landform: Mountains
Parent material: Ash over colluvium and residuum
Elevation: 3,000 to 4,000 feet
Native plants: Parrego soil—ponderosa pine, antelope bitterbrush, greenleaf manzanita, needlegrasses; Thorn soil—ponderosa pine, antelope bitterbrush, greenleaf manzanita, Idaho fescue
Climatic factors:
Mean annual precipitation—15 to 25 inches
Mean annual air temperature—40 to 47 degrees F
Frost-free period—50 to 90 days

Typical Profile of the Parrego Soil

3 inches to 0—organic mat
0 to 5 inches—dark brown sandy loam
5 to 13 inches—brown loam
13 to 24 inches—brown clay loam
24 inches—weathered tuff

Properties and Qualities of the Parrego Soil

Depth: Colluvium at a depth of 4 to 7 inches; soft bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 4 inches

Typical Profile of the Thorn Soil

1 inch to 0—organic mat
0 to 4 inches—dark brown gravelly sandy loam
4 to 8 inches—dark brown loam
8 to 16 inches—dark brown extremely stony loam
16 inches—andesite

Properties and Qualities of the Thorn Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 2 inches

Contrasting Inclusions

- Smiling soils on side slopes
- Windego soils on ridges

Major Use

Woodland

Major Management Limitations

Parrego and Thorn soils—Rock outcrop, climate, slope, low fertility
Thorn soil—soil depth, susceptibility to compaction

General Management Considerations

- Seedlings have a moderate survival rate because of the low precipitation.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because roots are restricted by the shallow depth of the Thorn soil, trees are subject to windthrow.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.

- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Using machinery only in areas covered with logging slash or brush reduces soil displacement.
- Because of the moderate susceptibility of the Thorn soil to compaction, designated skid trails should be used.

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Parrego soil—*CP-S2-13*
Thorn soil—*CP-S2-17*

97—Pits

Setting

Landform: Cinder cones
Slope: 0 to 65 percent
Elevation: 2,500 to 5,000 feet
Climatic factors:
    Mean annual precipitation—10 to 25 inches
    Mean annual air temperature—41 to 52 degrees F
    Frost-free period—50 to 140 days

Major Use

Source of road paving material

98A—Plainview sandy loam, 0 to 3 percent slopes

Composition

Plainview soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Outwash plains (fig. 9)
Parent material: Ash over glacial outwash
Elevation: 3,000 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread
Climatic factors:
    Mean annual precipitation—10 to 12 inches
    Mean annual air temperature—47 to 52 degrees F
    Frost-free period—70 to 100 days

Typical Profile

0 to 23 inches—dark grayish brown and brown sandy loam
23 to 39 inches—pale brown very gravelly and extremely gravelly sandy loam
39 to 55 inches—light brownish gray very gravelly loamy sand
55 to 60 inches—very dark grayish brown indurated duripan

Soil Properties and Qualities

Depth: Glacial outwash at a depth of 20 to 40 inches; duripan at a depth of 50 to 65 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 5 inches

Contrasting Inclusions

- Tumalo soils on outwash plains
- Soils that have a duripan at a depth of more than 60 inches

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Surface texture, permeability

General Management Considerations

Irrigated cropland

- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.

Figure 9.—Typical area of Plainview sandy loam, 0 to 3 percent slopes, in foreground. Three Sisters Mountains in background.

Range Site

Pumice Flat 10-12pz

98B—Plainview sandy loam, 3 to 8 percent slopes

Composition

Plainview soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Outwash plains
Parent material: Ash over glacial outwash
Elevation: 3,000 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—70 to 100 days

Typical Profile

0 to 23 inches—dark grayish brown and brown sandy loam
23 to 39 inches—pale brown very gravelly and extremely gravelly sandy loam
39 to 55 inches—light brownish gray very gravelly loamy sand
55 to 60 inches—very dark grayish brown indurated duripan

Soil Properties and Qualities

Depth: Glacial outwash at a depth of 20 to 40 inches; duripan at a depth of 50 to 65 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 5 inches

Contrasting Inclusions

- Tumalo soils on outwash plains

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Surface texture, permeability, slope

General Management Considerations

Irrigated cropland

- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.
- Because of the steepness of slope, sprinkler irrigation systems should be used to minimize runoff.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.

Range Site

Pumice Flat 10-12pz

99C—Prairie-Gap complex, 0 to 15 percent slopes

Composition

Prairie soil and similar inclusions—45 percent
Gap soil and similar inclusions—45 percent
Contrasting inclusions—10 percent

Setting

Landform: Mountains
Parent material: Ash over residuum and colluvium
Elevation: 4,000 to 5,000 feet
Native plants: Ponderosa pine, Douglas fir, white fir, common snowberry, pinegrass
Climatic factors:
Mean annual precipitation—25 to 35 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—10 to 50 days

Typical Profile of the Prairie Soil

3 inches to 0—organic mat
0 to 16 inches—dark brown and dark yellowish brown sandy loam
16 to 22 inches—dark brown gravelly loam
22 to 37 inches—dark brown cobbly loam
37 inches—weathered basalt

Properties and Qualities of the Prairie Soil

Depth: Colluvium at a depth of 14 to 20 inches; soft bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 5 inches

Typical Profile of the Gap Soil

4 inches to 0—organic mat
0 to 14 inches—dark brown and reddish brown sandy loam

14 to 18 inches—reddish brown loam
18 to 47 inches—dark brown and reddish brown clay loam
47 inches—weathered tuff

Properties and Qualities of the Gap Soil

Depth: Colluvium at a depth of 14 to 20 inches; soft bedrock at a depth of 40 to 60 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 8 inches

Contrasting Inclusions

- Glaze soils on ridges

Major Use

Woodland

Major Management Limitations

Prairie and Gap soils—low fertility, susceptibility to compaction
Prairie soil—soil depth

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- On the Prairie soil, reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CD-S6-14

99D—Prairie-Gap complex, 15 to 30 percent slopes

Composition

Prairie soil and similar inclusions—45 percent
Gap soil and similar inclusions—45 percent
Contrasting inclusions—10 percent

Setting

Landform: Mountains
Parent material: Ash over residuum and colluvium
Elevation: 4,000 to 5,000 feet
Native plants: Ponderosa pine, Douglas fir, white fir, common snowberry, pinegrass
Climatic factors:
Mean annual precipitation—25 to 35 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—10 to 50 days

Typical Profile of the Prairie Soil

3 inches to 0—organic mat
0 to 16 inches—dark brown and dark yellowish brown sandy loam
16 to 22 inches—dark brown gravelly loam
22 to 37 inches—dark brown cobbly loam
37 inches—weathered tuff

Properties and Qualities of the Prairie Soil

Depth: Colluvium at a depth of 14 to 20 inches; soft bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 5 inches

Typical Profile of the Gap Soil

4 inches to 0—organic mat
0 to 14 inches—dark brown and reddish brown sandy loam
14 to 18 inches—reddish brown loam
18 to 47 inches—dark brown and reddish brown clay loam
47 inches—weathered tuff

Properties and Qualities of the Gap Soil

Depth: Colluvium at a depth of 14 to 20 inches; soft bedrock at a depth of 40 to 60 inches or more
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 8 inches

Contrasting Inclusions

- Glaze soils on ridges

Major Use

Woodland

Major Management Limitations

Prairie and Gap soils—slope, low fertility, susceptibility to compaction
Prairie soil—soil depth

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Wheeled and tracked equipment can be used;

however, cable yarding generally is safer and disturbs the soil less.

- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CD-S6-14

100C—Redcliff-Lickskillet complex, 0 to 15 percent slopes

Composition

Redcliff soil and similar inclusions—60 percent
Lickskillet soil and similar inclusions—25 percent
Contrasting inclusions—15 percent

Setting

Landscape position: Toe slopes
Landform: Hills
Parent material: Colluvium
Elevation: 2,000 to 4,500 feet
Native plants: Wyoming big sagebrush, bluebunch wheatgrass, Thurber needlegrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—70 to 100 days

Typical Profile of the Redcliff Soil

0 to 10 inches—grayish brown cobbly sandy loam
10 to 25 inches—pale brown very cobbly sandy loam
25 to 34 inches—pale brown extremely cobbly sandy loam
34 inches—basalt

Properties and Qualities of the Redcliff Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 2 inches

Typical Profile of the Lickskillet Soil

0 to 7 inches—dark brown very stony sandy loam
7 to 14 inches—dark brown very cobbly sandy loam
14 inches—tuff

Properties and Qualities of the Lickskillet Soil

Depth: Bedrock at a depth of 12 to 20 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 1 inch

Contrasting Inclusions

- Deep soils that are sandy loam and are on north- and south-facing slopes

Major Use

Livestock grazing

Major Management Limitations

Soil depth, permeability, rock fragments in surface layer

General Management Considerations

- Pond development is limited by the soil depth, risk of seepage, and steepness of slope in some areas.
- The restricted depth of the Lickskillet soil limits the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface.

Range Site

Droughty 8-12pz

101D—Redcliff-Lickskillet-Rock outcrop complex, 15 to 30 percent south slopes

Composition

Redcliff soil and similar inclusions—60 percent
Lickskillet soil and similar inclusions—20 percent
Rock outcrop—15 percent
Contrasting inclusions—5 percent

Setting

Landscape position: Redcliff soil—toe slopes; Lickskillet soil—upper slopes
Landform: Canyonsides
Parent material: Colluvium
Elevation: 2,000 to 4,500 feet
Native plants: Western juniper, Wyoming big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Sandberg bluegrass

Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—70 to 100 days

Typical Profile of the Redcliff Soil

0 to 10 inches—grayish brown cobbly sandy loam
10 to 25 inches—pale brown very cobbly sandy loam
25 to 34 inches—pale brown extremely cobbly sandy loam
34 inches—basalt

Properties and Qualities of the Redcliff Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 2 inches

Typical Profile of the Lickskillet Soil

0 to 7 inches—dark brown very stony sandy loam
7 to 14 inches—dark brown very cobbly sandy loam
14 inches—tuff

Properties and Qualities of the Lickskillet Soil

Depth: Bedrock at a depth of 12 to 20 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 1 inch

Contrasting Inclusions

- Soils that are deep sandy loam

Major Use

Livestock grazing

Major Management Limitations

Rock outcrop, soil depth, permeability, rock fragments in surface layer, slope

General Management Considerations

- Pond development is limited by the soil depth, risk of seepage, and steepness of slope.
- The restricted depth of the Lickskillet soil limits the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface.
- The areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

South 9-12pz

101E—Redcliff-Lickskillet-Rock outcrop complex, 30 to 50 percent south slopes

Composition

Redcliff soil and similar inclusions—60 percent
Lickskillet soil and similar inclusions—20 percent
Rock outcrop—15 percent
Contrasting inclusions—5 percent

Setting

Landscape position: Redcliff soil—toe slopes; Lickskillet soil—upper slopes
Landform: Canyonsides
Parent material: Colluvium
Elevation: 2,000 to 4,500 feet
Native plants: Western juniper, Wyoming big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—70 to 100 days

Typical Profile of the Redcliff Soil

0 to 10 inches—grayish brown cobbly sandy loam
10 to 25 inches—pale brown very cobbly sandy loam
25 to 34 inches—pale brown extremely cobbly sandy loam
34 inches—basalt

Properties and Qualities of the Redcliff Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 2 inches

Typical Profile of the Lickskillet Soil

0 to 7 inches—dark brown very stony sandy loam
7 to 14 inches—dark brown very cobbly sandy loam
14 inches—tuff

Properties and Qualities of the Lickskillet Soil

Depth: Bedrock at a depth of 12 to 20 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 1 inch

Contrasting Inclusions

- Soils that are deep sandy loam

Major Use

Livestock grazing

Major Management Limitations

Rock outcrop, soil depth, permeability, rock fragments in surface layer, slope, aspect

General Management Considerations

- Pond development is limited by the soil depth, risk of seepage, and steepness of slope.
- The restricted depth of the Lickskillet soil limits the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface, the steepness of slope, and the areas of Rock outcrop.
- The areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.
- The steepness of slope restricts livestock distribution and limits range seeding with ground equipment.
- The steep, south-facing slopes are less suited to grazing in hot periods during the grazing season.

Range Site

South 9-12pz

102D—Redcliff-Rock outcrop complex, 5 to 30 percent slopes

Composition

Redcliff soil and similar inclusions—60 percent
Rock outcrop—25 percent
Contrasting inclusions—15 percent

Setting

Landform: Hills
Parent material: Colluvium
Elevation: 3,000 to 4,500 feet
Native plants: Western juniper, Wyoming big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—9 to 12 inches
Mean annual air temperature—46 to 48 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 19 inches—brown very gravelly loam
19 to 25 inches—dark yellowish brown extremely gravelly clay loam
25 inches—fractured rhyolite

Soil Properties and Qualities

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 2 inches

Contrasting Inclusions

- Westbutte soils on steep, north-facing hillsides
- Stookmoor soils on hillsides
- Lickskillet soils near areas of Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Rock outcrop, climate, soil depth

General Management Considerations

- Pond development is limited by the soil depth and the steepness of slope in some areas.
- Range seeding with ground equipment is limited by the areas of Rock outcrop.
- The areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

South 9-12pz

103E—Redcliff-Rock outcrop complex, 30 to 65 percent south slopes

Composition

Redcliff soil and similar inclusions—65 percent
Rock outcrop—20 percent
Contrasting inclusions—15 percent

Setting

Landform: Hills
Parent material: Colluvium
Elevation: 3,000 to 5,500 feet
Native plants: Western juniper, Wyoming big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—9 to 12 inches
Mean annual air temperature—46 to 48 degrees F
Frost-free period—50 to 90 days

Typical Profile of the Redcliff Soil

0 to 19 inches—brown very gravelly loam

19 to 25 inches—dark yellowish brown extremely gravelly clay loam
25 inches—fractured rhyolite

Properties and Qualities of the Redcliff Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 2 inches

Contrasting Inclusions

- Westbutte soils on steep, north-facing hillsides
- Stookmoor soils on hillsides
- Lickskillet soils near areas of Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Rock outcrop, climate, soil depth, slope

General Management Considerations

- Pond development is limited by the soil depth and steepness of slope.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.
- The areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.
- The steepness of slope restricts livestock distribution and limits range seeding with ground equipment.
- The steep, south-facing slopes are less suited to grazing in hot periods during the grazing season.

Range Site

South 9-12pz

104A—Redmond sandy loam, 0 to 3 percent slopes

Composition

Redmond soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 3,000 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, needleandthread, Idaho fescue, western needlegrass
Climatic factors:
Mean annual precipitation—8 to 10 inches
Mean annual air temperature—49 to 52 degrees F
Frost-free period—80 to 100 days

Typical Profile

0 to 12 inches—grayish brown sandy loam
12 to 21 inches—grayish brown loam
21 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 4 inches

Contrasting Inclusions

- Buckbert, Deschutes, and Houstake soils in swales
- Stukel soils on ridges

Major Uses

Irrigated cropland (fig. 10), livestock grazing

Figure 10.—Irrigated pasture in an area of Redmond sandy loam, 0 to 3 percent slopes.

Major Management Limitations

Soil depth, surface texture, permeability, climate

General Management Considerations

Irrigated cropland

- Well-managed irrigation systems are needed for deep-rooted crops such as alfalfa.
- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash,

reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.

- Pond development is limited by the soil depth and risk of seepage.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Pumice Flat 8-10pz

105C—Redmond-Deschutes-Stukel complex, 0 to 15 percent slopes

Composition

Redmond soil and similar inclusions—40 percent
Deschutes soil and similar inclusions—30 percent
Stukel soil and similar inclusions—20 percent
Contrasting inclusions—10 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 2,500 to 4,000 feet
Native plants: Redmond and Deschutes soils—western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread; Stukel soil—western juniper, mountain big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
  Mean annual precipitation—10 to 12 inches
  Mean annual air temperature—47 to 50 degrees F
  Frost-free period—70 to 90 days

Typical Profile of the Redmond Soil

0 to 12 inches—grayish brown sandy loam
12 to 21 inches—grayish brown loam
21 inches—basalt

Properties and Qualities of the Redmond Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 4 inches

Typical Profile of the Deschutes Soil

0 to 17 inches—grayish brown sandy loam
17 to 31 inches—light grayish brown sandy loam
31 inches—basalt

Properties and Qualities of the Deschutes Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 4 inches

Typical Profile of the Stukel Soil

0 to 4 inches—grayish brown sandy loam
4 to 11 inches—brown cobbly sandy loam
11 to 18 inches—pale brown gravelly sandy loam
18 inches—basalt

Properties and Qualities of the Stukel Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Contrasting Inclusions

- Soils that have a gravelly substratum
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Surface texture, soil depth, permeability

General Management Considerations

- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and risk of seepage.
- The restricted depth of the Stukel soil limits the choice of species for range seeding to drought-tolerant varieties.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Redmond and Deschutes soils—Pumice Flat 10-12pz
Stukel soil—Lava Blisters 10-12pz

106D—Redslide-Lickskillet complex, 15 to 30 percent north slopes

Composition

Redslide soil and similar inclusions—50 percent
Lickskillet soil and similar inclusions—35 percent
Contrasting inclusions—15 percent

Setting

Landscape position: Redslide soil—toe slopes; Lickskillet soil—upper slopes
Landform: Canyonsides
Parent material: Colluvium
Elevation: 2,000 to 4,000 feet
Native plants: Redslide soil—western juniper, antelope bitterbrush, mountain big sagebrush, Idaho fescue, bluebunch wheatgrass; Lickskillet soil—western juniper, mountain big sagebrush, bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—70 to 100 days

Typical Profile of the Redslide Soil

0 to 4 inches—grayish brown stony sandy loam
4 to 21 inches—brown very cobbly sandy loam
21 to 34 inches—brown extremely cobbly sandy loam
34 inches—fractured rhyolite

Properties and Qualities of the Redslide Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Typical Profile of the Lickskillet Soil

0 to 7 inches—dark brown very stony sandy loam
7 to 14 inches—dark brown very cobbly sandy loam
14 inches—tuff

Properties and Qualities of the Lickskillet Soil

Depth: Bedrock at a depth of 12 to 20 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 1 inch

Contrasting Inclusions

- Soils that are deep sandy loam
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Soil depth, permeability, rock fragments in surface layer, slope

General Management Considerations

- Pond development is limited by the soil depth, risk of seepage, and steepness of slope.
- The restricted depth of the Lickskillet soil limits the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Redslide soil—Sandy North 9-14pz
Lickskillet soil—Shallow North 9-12pz

106E—Redslide-Lickskillet complex, 30 to 50 percent north slopes

Composition

Redslide soil and similar inclusions—50 percent
Lickskillet soil and similar inclusions—35 percent
Contrasting inclusions—15 percent

Setting

Landscape position: Redslide soil—toe slopes; Lickskillet soil—upper slopes
Landform: Canyonsides
Parent material: Colluvium
Elevation: 2,000 to 4,000 feet
Native plants: Redslide soil—western juniper, antelope bitterbrush, mountain big sagebrush, Idaho fescue, bluebunch wheatgrass; Lickskillet soil—western juniper, mountain big sagebrush, bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—70 to 100 days

Typical Profile of the Redslide Soil

0 to 4 inches—grayish brown stony sandy loam
4 to 21 inches—brown very cobbly sandy loam
21 to 34 inches—brown extremely cobbly sandy loam
34 inches—fractured rhyolite

Properties and Qualities of the Redslide Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Typical Profile of the Lickskillet Soil

0 to 7 inches—dark brown very stony sandy loam
7 to 14 inches—dark brown very cobbly sandy loam
14 inches—tuff

Properties and Qualities of the Lickskillet Soil

Depth: Bedrock at a depth of 12 to 20 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 1 inch

Contrasting Inclusions

- Soils that are deep sandy loam
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Soil depth, permeability, rock fragments in surface layer, slope

General Management Considerations

- Pond development is limited by the soil depth, risk of seepage, and steepness of slope.
- The restricted depth of the Lickskillet soil limits the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface and the steepness of slope.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.
- The steepness of slope restricts livestock distribution and makes range seeding with ground equipment impractical.

Range Site

Redslide soil—Sandy North 9-14pz
Lickskillet soil—Shallow North 9-12pz

107B—Reluctan sandy loam, 1 to 8 percent slopes

Composition

Reluctan soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Residuum derived from basalt and welded tuff with ash on the surface
Elevation: 4,100 to 5,000 feet
Native plants: Stiff sagebrush, Sandberg bluegrass, bluebunch wheatgrass, bottlebrush squirreltail
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 4 inches—grayish brown sandy loam
4 to 10 inches—brown sandy loam
10 to 35 inches—brown and pale brown gravelly clay loam
35 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 4 inches

Contrasting Inclusions

- Shallow soils that have a duripan over bedrock
- Ninemile soils on lava plains
- Beden soils on lower toe slopes
- Swaler soils in basins
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Climate, surface texture, soil depth

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Droughty Pumice 9-12pz

108C—Reluctan loam, 2 to 20 percent slopes

Composition

Reluctan soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Residuum derived from basalt and welded tuff
Elevation: 4,100 to 5,000 feet
Native plants: Idaho fescue, bluebunch wheatgrass, basin big sagebrush, Thurber needlegrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 10 inches—grayish brown loam
10 to 25 inches—brown clay loam
25 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 4 inches

Contrasting Inclusions

- Shallow soils that have a duripan over bedrock
- Beden soils on lower toe slopes
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Climate, soil depth

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Pond development is limited by the soil depth and by the steepness of slope in some areas.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Droughty Loam 11-13pz

109—Rock outcrop

Composition

Rock outcrop—85 percent
Contrasting inclusions—15 percent

Setting

Slope: 20 to 65 percent
Elevation: 2,500 to 5,000 feet
Climatic factors:
Mean annual precipitation—10 to 15 inches
Mean annual air temperature—41 to 45 degrees F
Frost-free period—50 to 90 days

Description of Rock outcrop

Outcroppings of volcanic rock

Contrasting Inclusions

- Soils that have bedrock at a depth of 1 inch to 20 inches

Major Use

Wildlife habitat

110D—Schrier-Tub complex, 15 to 30 percent north slopes

Composition

Schrier soil and similar inclusions—45 percent
Tub soil and similar inclusions—40 percent
Contrasting inclusions—15 percent

Setting

Landscape position: Side slopes
Landform: Hills
Parent material: Loess over colluvium
Elevation: 2,600 to 4,500 feet
Native plants: Mountain big sagebrush, Idaho fescue, bluebunch wheatgrass
Climatic factors:
Mean annual precipitation—12 to 14 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—110 to 130 days

Typical Profile of the Schrier Soil

0 to 16 inches—very dark grayish brown silt loam
16 to 21 inches—dark brown very gravelly silt loam
21 to 42 inches—dark brown silt loam
42 to 60 inches—dark brown extremely gravelly fine sand

Properties and Qualities of the Schrier Soil

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 10 inches

Typical Profile of the Tub Soil

0 to 14 inches—dark grayish brown loam
14 to 24 inches—brown clay loam
24 to 28 inches—brown very cobbly clay
28 to 41 inches—brown cobbly clay
41 inches—rhyolite

Properties and Qualities of the Tub Soil

Depth: Bedrock at a depth of 40 to 60 inches
Drainage class: Well drained
Permeability: Slow
Available water capacity: About 6 inches

Contrasting Inclusions

- Simas soils that are on side slopes and ridges and support low sagebrush
- Era soils in swales
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitation

Slope

General Management Considerations

- Pond development is limited by the steepness of slope.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Droughty North 9-12pz

110E—Schrier-Tub complex, 30 to 60 percent north slopes

Composition

Schrier soil and similar inclusions—45 percent
Tub soil and similar inclusions—40 percent
Contrasting inclusions—15 percent

Setting

Landscape position: Side slopes
Landform: Hills
Parent material: Loess over colluvium
Elevation: 2,600 to 4,500 feet
Native plants: Mountain big sagebrush, Idaho fescue, bluebunch wheatgrass
Climatic factors:
Mean annual precipitation—12 to 14 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—110 to 130 days

Typical Profile of the Schrier Soil

0 to 16 inches—very dark grayish brown silt loam
16 to 21 inches—dark brown very gravelly silt loam
21 to 42 inches—dark brown silt loam
42 to 60 inches—dark brown extremely gravelly fine sand

Properties and Qualities of the Schrier Soil

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 10 inches

Typical Profile of the Tub Soil

0 to 14 inches—dark grayish brown loam
14 to 24 inches—brown clay loam
24 to 28 inches—brown very cobbly clay
28 to 41 inches—brown cobbly clay
41 inches—rhyolite

Properties and Qualities of the Tub Soil

Depth: Bedrock at a depth of 40 to 60 inches
Drainage class: Well drained
Permeability: Slow
Available water capacity: About 6 inches

Contrasting Inclusions

- Simas soils that are on side slopes and ridges and support low sagebrush
- Era soils in swales
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitation

Slope

General Management Considerations

- Pond development is limited by the steepness of slope.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.
- The steepness of slope restricts livestock distribution and limits range seeding with ground equipment.

Range Site

Droughty North 9-12pz

111D—Searles-Holmzie complex, 15 to 30 percent slopes

Composition

Searles soil and similar inclusions—50 percent
Holmzie soil and similar inclusions—35 percent
Contrasting inclusions—15 percent

Setting

Landform: Hills
Parent material: Ash over residuum
Elevation: 3,000 to 3,500 feet
Native plants: Western juniper, Wyoming big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—9 to 11 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—70 to 90 days

Typical Profile of the Searles Soil

0 to 7 inches—grayish brown sandy loam
7 to 13 inches—brown loam
13 to 24 inches—brown and yellowish brown very gravelly loam and very gravelly clay loam
24 inches—basalt

Properties and Qualities of the Searles Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 3 inches

Typical Profile of the Holmzie Soil

0 to 7 inches—dark grayish brown loam
7 to 19 inches—brown clay loam
19 to 29 inches—reddish brown gravelly clay
29 inches—weathered tuff

Properties and Qualities of the Holmzie Soil

Depth: Soft bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Slow
Available water capacity: About 5 inches

Contrasting Inclusions

- Soils that are on ridges and have bedrock at a depth of 10 to 20 inches
- Soils that are in swales and have a clay or clay loam subsoil over a strongly cemented layer at a depth of 20 to 40 inches
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Searles and Holmzie soils—soil depth, climate, slope
Searles soil—surface texture

General Management Considerations

- Care should be taken to protect the Searles soil from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and steepness of slope.
- The low annual precipitation limits productivity and limits the choice of species for range seeding to drought-tolerant varieties.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

South 9-12pz

112D—Searles-Holmzie complex, moist, 15 to 30 percent slopes

Composition

Searles soil and similar inclusions—50 percent
Holmzie soil and similar inclusions—35 percent
Contrasting inclusions—15 percent

Setting

Landform: Hills
Parent material: Ash over residuum
Elevation: 3,500 to 4,000 feet
Native plants: Ponderosa pine, western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, Ross sedge
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—70 to 90 days

Typical Profile of the Searles Soil

0 to 7 inches—grayish brown sandy loam
7 to 13 inches—brown loam
13 to 24 inches—brown and yellowish brown very gravelly loam and very gravelly clay loam
24 inches—basalt

Properties and Qualities of the Searles Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 3 inches

Typical Profile of the Holmzie Soil

0 to 7 inches—dark grayish brown loam
7 to 19 inches—brown clay loam
19 to 29 inches—reddish brown gravelly clay
29 inches—weathered tuff

Properties and Qualities of the Holmzie Soil

Depth: Soft bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Slow
Available water capacity: About 5 inches

Contrasting Inclusions

- Soils that are on ridges and have bedrock at a depth of 10 to 20 inches
- Soils that have a stony or very stony surface layer
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Soil depth, slope

General Management Considerations

- Pond development is limited by the soil depth and steepness of slope.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Pine-Juniper-Bitterbrush-Fescue

113C—Searles-Statz complex, 0 to 15 percent slopes

Composition

Searles soil and similar inclusions—45 percent
Statz soil and similar inclusions—40 percent
Contrasting inclusions—15 percent

Setting

Landform: Hills
Parent material: Searles soil—ash over residuum; Statz soil—ash
Elevation: 2,000 to 4,000 feet
Native plants: Searles soil—Wyoming big sagebrush, bluebunch wheatgrass, Thurber needlegrass, Sandberg bluegrass; Statz soil—western juniper, mountain big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—70 to 100 days

Typical Profile of the Searles Soil

0 to 7 inches—grayish brown sandy loam
7 to 13 inches—brown loam
13 to 24 inches—brown and yellowish brown very gravelly loam and very gravelly clay loam
24 inches—basalt

Properties and Qualities of the Searles Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 3 inches

Typical Profile of the Statz Soil

0 to 14 inches—grayish brown sandy loam
14 to 20 inches—brown sandy loam
20 to 25 inches—indurated duripan
25 inches—basalt

Properties and Qualities of the Statz Soil

Depth: Duripan at a depth of 10 to 20 inches; bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Contrasting Inclusions

- Rock outcrop
- Lickskillet soils

Major Use

Livestock grazing

Major Management Limitations

Surface texture, soil depth

General Management Considerations

- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and the steepness of slope in some areas.
- The restricted depth to the duripan in the Statz soil

limits the choice of species for range seeding to drought-tolerant varieties.

- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Searles soil—Droughty 8-12pz
Statz soil—Lava Blisters 10-12pz

114C—Shanahan loamy coarse sand, 0 to 15 percent slopes

Composition

Shanahan soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landform: Pumice-mantled lava plains
Parent material: Ash over old alluvium
Elevation: 4,500 to 6,000 feet
Native plants: Ponderosa pine, antelope bitterbrush, Idaho fescue
Climatic factors:
Mean annual precipitation—18 to 25 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—20 to 50 days

Typical Profile

1 inch to 0—organic mat
0 to 8 inches—brown loamy coarse sand
8 to 26 inches—very pale brown and light yellowish brown gravelly loamy coarse sand, loamy coarse sand, and coarse sand
26 to 44 inches—brown and yellowish brown sandy loam and gravelly sandy loam
44 to 61 inches—very dark gray very gravelly coarse sand

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Moderately rapid over very rapid
Available water capacity: About 7 inches

Contrasting Inclusions

- Sunriver soils in depressions
- Cryaquolls in depressions
- Steiger soils south of LaPine

Major Use

Woodland

Major Management Limitations

Rooting depth, surface texture, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because this coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CP-S2-11

114D—Shanahan loamy coarse sand, 15 to 30 percent slopes

Composition

Shanahan soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landform: Pumice-mantled hills
Parent material: Ash over colluvium
Elevation: 4,500 to 6,000 feet
Native plants: Ponderosa pine, antelope bitterbrush, Idaho fescue
Climatic factors:
Mean annual precipitation—18 to 25 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—20 to 50 days

Typical Profile

1 inch to 0—organic mat
0 to 8 inches—brown loamy coarse sand
8 to 26 inches—very pale brown and light yellowish

brown gravelly loamy coarse sand, loamy coarse sand, and coarse sand
26 to 61 inches—brown and yellowish brown sandy loam and gravelly sandy loam

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Moderately rapid
Available water capacity: About 7 inches

Contrasting Inclusions

- Sunriver soils in depressions
- Steiger soils south of LaPine

Major Use

Woodland

Major Management Limitations

Rooting depth, slope, surface texture, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Wheeled and tracked equipment can be used; however, cable yarding generally is safer and disturbs the soil less.
- Because this coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CP-S2-11

115A—Shanahan loamy coarse sand, low, 0 to 3 percent slopes

Composition

Shanahan soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landscape position: Depressions
Landform: Pumice-mantled lava plains
Parent material: Ash over old alluvium
Elevation: 4,000 to 4,500 feet
Native plants: Lodgepole pine, antelope bitterbrush, and Idaho fescue
Climatic factors:
Mean annual precipitation—18 to 25 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—10 to 30 days

Typical Profile

1 inch to 0—organic mat
0 to 8 inches—brown loamy coarse sand
8 to 26 inches—very pale brown and light yellowish brown loamy coarse sand and coarse sand
26 to 44 inches—brown and yellowish brown sandy loam and gravelly sandy loam
44 to 61 inches—very dark gray very gravelly coarse sand

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Moderately rapid over very rapid
Available water capacity: About 7 inches

Contrasting Inclusions

- Sunriver soils in depressions
- Cryaquolls in depressions
- Steiger soils south of LaPine

Major Use

Woodland

Major Management Limitations

Frost heaving, rooting depth, surface texture, low fertility, susceptibility to compaction

General Management Considerations

- Severe frost or frost heaving can damage or kill seedlings.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.

- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because this coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CL-S2-14

116E—Shroyton loamy sand, 30 to 50 percent slopes

Composition

Shroyton soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Mountains
Parent material: Ash
Elevation: 4,500 to 6,400 feet
Native plants: Ponderosa pine, Douglas fir, white fir, common snowberry, pinegrass
Climatic factors:
Mean annual precipitation—30 to 50 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—10 to 50 days

Typical Profile

2 inches to 0—organic mat
0 to 15 inches—brown loamy sand
15 to 31 inches—brown gravelly coarse sandy loam
31 to 55 inches—yellowish brown gravelly sandy loam
55 inches—andesite

Soil Properties and Qualities

Depth: Bedrock at a depth of 40 to 60 inches
Drainage class: Well drained
Permeability: Rapid
Available water capacity: About 6 inches

Contrasting Inclusions

- Sisters and Yapoah soils at lower elevations
- Soils that have a very gravelly or very cobbly subsoil
- Rock outcrop

Major Use

Woodland

Major Management Limitations

Slope, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Using machinery only in areas covered with logging slash or brush reduces soil displacement.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CD-S6-14

117C—Simas silt loam, 0 to 15 percent slopes

Composition

Simas soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Hills
Parent material: Loess over colluvium
Elevation: 2,600 to 3,500 feet
Native plants: Western juniper, low sagebrush, antelope bitterbrush, Idaho fescue, bluebunch wheatgrass
Climatic factors:
Mean annual precipitation—9 to 12 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—110 to 140 days

Typical Profile

0 to 5 inches—dark grayish brown silt loam
5 to 21 inches—dark grayish brown cobbly clay
21 to 60 inches—yellowish brown gravelly clay

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Slow
Available water capacity: About 7 inches

Contrasting Inclusions

- Soils that do not have an abrupt clay increase in the subsoil

Major Use

Livestock grazing

Major Management Limitation

Depth to claypan

General Management Considerations

- Shallow rooting depth limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Droughty Claypan 10-12pz

118D—Simas-Ruckles complex, 15 to 40 percent north slopes

Composition

Simas soil and similar inclusions—50 percent
Ruckles soil and similar inclusions—35 percent
Contrasting inclusions—15 percent

Setting

Landscape position: Simas soil—toe slopes; Ruckles soil—midslopes
Landform: Canyons
Parent material: Colluvium
Elevation: 1,400 to 2,600 feet
Native plants: Wyoming big sagebrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
  Mean annual precipitation—9 to 11 inches
  Mean annual air temperature—47 to 50 degrees F
  Frost-free period—110 to 140

Typical Profile of the Simas Soil

0 to 12 inches—dark grayish brown cobbly loam
12 to 37 inches—dark grayish brown and brown cobbly clay and clay
37 to 60 inches—yellowish brown gravelly clay

Properties and Qualities of the Simas Soil

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Slow
Available water capacity: About 7 inches

Typical Profile of the Ruckles Soil

0 to 9 inches—dark grayish brown extremely cobbly loam
9 to 14 inches—brown extremely cobbly clay loam
14 to 18 inches—light yellowish brown cobbly clay
18 to 19 inches—weathered tuff
19 inches—welded tuff

Properties and Qualities of the Ruckles Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Slow
Available water capacity: About 1 inch

Contrasting Inclusions

- Soils that are similar to the Simas soil but are more than 35 percent rock fragments throughout
- Very shallow soils associated with exposed bedrock

Major Use

Livestock grazing

Major Management Limitations

Simas and Ruckles soils—rock fragments in surface layer, slope
Ruckles soil—soil depth, available water capacity

General Management Considerations

- Pond development is limited by the steepness of slope.
- The low available water capacity and the restricted depth of the Ruckles soil limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface.
- The steepness of slope restricts livestock distribution and limits range seeding with ground equipment.

Range Site

Droughty North 9-12pz

119D—Simas-Ruckles complex, 15 to 40 percent south slopes

Composition

Simas soil and similar inclusions—50 percent
Ruckles soil and similar inclusions—35 percent
Contrasting inclusions—15 percent

Setting

Landscape position: Simas soil—toe slopes; Ruckles soil—midslopes
Landform: Canyons
Parent material: Colluvium
Elevation: 1,400 to 2,600 feet
Native plants: Western juniper, Wyoming big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—9 to 11 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—110 to 140 days

Typical Profile of the Simas Soil

0 to 12 inches—dark grayish brown cobbly loam
12 to 37 inches—dark grayish brown and brown cobbly clay and clay
37 to 60 inches—yellowish brown gravelly clay

Properties and Qualities of the Simas Soil

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Slow
Available water capacity: About 7 inches

Typical Profile of the Ruckles Soil

0 to 9 inches—dark grayish brown extremely cobbly loam
9 to 14 inches—brown extremely cobbly clay loam
14 to 18 inches—light yellowish brown cobbly clay
18 to 19 inches—weathered tuff
19 inches—welded tuff

Properties and Qualities of the Ruckles Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Slow
Available water capacity: About 1 inch

Contrasting Inclusions

- Soils that are similar to the Simas soil but are more than 35 percent rock fragments throughout
- Very shallow soils associated with exposed bedrock

Major Use

Livestock grazing

Major Management Limitations

Simas and Ruckles soils—rock fragments in surface layer, slope, aspect
Ruckles soil—soil depth, available water capacity

General Management Considerations

- Pond development is limited by the steepness of slope.
- The low available water capacity and the restricted depth of the Ruckles soil limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface.
- The steepness of slope restricts livestock distribution and limits range seeding with ground equipment.
- The steep, south-facing slopes are less suited to grazing in hot periods during the grazing season.

Range Site

Droughty South 9-12pz

120F—Simas-Ruckles-Rock outcrop complex, 40 to 80 percent north slopes

Composition

Simas soil and similar inclusions—50 percent
Ruckles soil and similar inclusions—35 percent
Rock outcrop—10 percent
Contrasting inclusions—5 percent

Setting

Landscape position: Simas soil—toe slopes; Ruckles soil—midslopes; Rock outcrop—upper slopes
Landform: Canyons
Parent material: Colluvium
Elevation: 1,400 to 2,600 feet
Native plants: Wyoming big sagebrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
Mean annual precipitation—9 to 11 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—110 to 140

Typical Profile of the Simas Soil

0 to 12 inches—dark grayish brown cobbly loam

12 to 37 inches—dark grayish brown and brown cobbly clay and clay
37 to 60 inches—yellowish brown gravelly clay

Properties and Qualities of the Simas Soil

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Slow
Available water capacity: About 7 inches

Typical Profile of the Ruckles Soil

0 to 9 inches—dark grayish brown extremely cobbly loam
9 to 14 inches—brown extremely cobbly clay loam
14 to 18 inches—light yellowish brown cobbly clay
18 to 19 inches—weathered tuff
19 inches—welded tuff

Properties and Qualities of the Ruckles Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Slow
Available water capacity: About 1 inch

Contrasting Inclusions

- Soils that are similar to the Simas soil but are more than 35 percent rock fragments throughout
- Very shallow soils associated with exposed bedrock

Major Use

Livestock grazing

Major Management Limitations

Simas and Ruckles soils—Rock outcrop, rock fragments in surface layer, slope
Ruckles soil—soil depth, available water capacity

General Management Considerations

- Pond development is limited by the steepness of slope.
- The low available water capacity and the restricted depth of the Ruckles soil limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- The steepness of slope restricts livestock distribution and limits range seeding with ground equipment.
- The areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Droughty North 9-12pz

121F—Simas-Ruckles-Rock outcrop complex, 40 to 80 percent south slopes

Composition

Simas soil and similar inclusions—50 percent
Ruckles soil and similar inclusions—35 percent
Rock outcrop—10 percent
Contrasting inclusions—5 percent

Setting

Landscape position: Simas soil—toe slopes; Ruckles soil—midslopes; Rock outcrop—upper slopes
Landform: Canyons
Parent material: Colluvium
Elevation: 1,400 to 2,600 feet
Native plants: Western juniper, Wyoming big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—9 to 11 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—110 to 140 days

Typical Profile of the Simas Soil

0 to 12 inches—dark grayish brown cobbly loam
12 to 37 inches—dark grayish brown and brown cobbly clay and clay
37 to 60 inches—yellowish brown gravelly clay

Properties and Qualities of the Simas Soil

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Slow
Available water capacity: About 7 inches

Typical Profile of the Ruckles Soil

0 to 9 inches—dark grayish brown extremely cobbly loam
9 to 14 inches—brown extremely cobbly clay loam
14 to 18 inches—light yellowish brown cobbly clay
18 to 19 inches—weathered tuff
19 inches—welded tuff

Properties and Qualities of the Ruckles Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Slow
Available water capacity: About 1 inch

Contrasting Inclusions

- Soils that are similar to the Simas soil but are more than 35 percent rock fragments throughout

- Very shallow soils associated with exposed bedrock

Major Use

Livestock grazing

Major Management Limitations

Simas and Ruckles soils—Rock outcrop, rock fragments in surface layer, slope, aspect
Ruckles soil—soil depth, available water capacity

General Management Considerations

- Pond development is limited by the steepness of slope.
- The low available water capacity and the restricted depth of the Ruckles soil limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- The steepness of slope restricts livestock distribution and restricts range seeding with ground equipment.
- The steep, south-facing slopes are less suited to grazing in hot periods during the grazing season.
- The areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Droughty South 9-12pz

122C—Sisters loamy sand, 0 to 15 percent slopes

Composition

Sisters soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Mountains
Parent material: Ash over colluvium and residuum
Elevation: 3,200 to 5,000 feet
Native plants: Ponderosa pine, antelope bitterbrush, greenleaf manzanita, Idaho fescue
Climatic factors:
Mean annual precipitation—18 to 30 inches
Mean annual air temperature—40 to 47 degrees F
Frost-free period—50 to 90 days

Typical Profile

2 inches to 0—organic mat
0 to 23 inches—dark brown and dark yellowish brown loamy sand
23 to 35 inches—dark brown sandy loam
35 to 60 inches—dark reddish brown and dark brown clay loam and loam

Soil Properties and Qualities

Depth: Colluvium at a depth of 20 to 35 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Rapid over moderately slow
Available water capacity: About 8 inches

Contrasting Inclusions

- Fryrear and Wanoga soils on side slopes and ridges
- Yapoah soils on side slopes
- Rock outcrop

Major Use

Woodland

Major Management Limitations

Low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CP-S2-17

123C—Sisters-Yapoah complex, 0 to 15 percent slopes

Composition

Sisters soil and similar inclusions—50 percent
Yapoah soil and similar inclusions—35 percent
Contrasting inclusions—15 percent

Setting

Landform: Mountains
Parent material: Sisters soil—ash over colluvium and residuum; Yapoah soil—ash and colluvium
Elevation: 3,200 to 5,000 feet

Native plants: Ponderosa pine, antelope bitterbrush, greenleaf manzanita, Idaho fescue
Climatic factors:
Mean annual precipitation—18 to 30 inches
Mean annual air temperature—40 to 47 degrees F
Frost-free period—50 to 90 days

Typical Profile of the Sisters Soil

2 inches to 0—organic mat
0 to 23 inches—dark brown and dark yellowish brown loamy sand
23 to 35 inches—dark brown sandy loam
35 to 60 inches—dark reddish brown and dark brown clay loam and loam

Properties and Qualities of the Sisters Soil

Depth: Colluvium at a depth of 20 to 35 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Rapid over moderately slow
Available water capacity: About 8 inches

Typical Profile of the Yapoah Soil

2 inches to 0—organic mat
0 to 12 inches—dark brown very cobbly loamy sand
12 to 60 inches—dark yellowish brown extremely flaggy loamy sand

Properties and Qualities of the Yapoah Soil

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Rapid
Available water capacity: About 2 inches

Contrasting Inclusions

- Fryrear soils on side slopes and ridges
- Wanoga soils on side slopes
- Rock outcrop

Major Use

Woodland

Major Management Limitations

Sisters soil—low fertility, susceptibility to compaction
Yapoah soil—rock fragments, available water capacity

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Because of the low fertility of the subsoil in the Sisters soil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility of the Sisters soil to compaction, designated skid trails should be used.
- Seedlings on the Yapoah soil have a poor survival rate because of the low available water capacity.
- Rock fragments in the Yapoah soil restrict the planting of seedlings.

Forest Service Plant Association

CP-S2-17

123D—Sisters-Yapoah complex, 15 to 30 percent slopes

Composition

Sisters soil and similar inclusions—50 percent
Yapoah soil and similar inclusions—35 percent
Contrasting inclusions—15 percent

Setting

Landform: Mountains
Parent material: Sisters soil—ash over colluvium and residuum; Yapoah soil—ash and colluvium
Elevation: 3,200 to 5,000 feet
Native plants: Ponderosa pine, antelope bitterbrush, greenleaf manzanita, Idaho fescue
Climatic factors:
Mean annual precipitation—18 to 30 inches
Mean annual air temperature—40 to 47 degrees F
Frost-free period—50 to 90 days

Typical Profile of the Sisters Soil

2 inches to 0—organic mat
0 to 23 inches—dark brown and dark yellowish brown loamy sand
23 to 35 inches—dark brown sandy loam
35 to 60 inches—dark reddish brown and dark brown clay loam and loam

Properties and Qualities of the Sisters Soil

Depth: Colluvium at a depth of 20 to 35 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained

Permeability: Rapid over moderately slow
Available water capacity: About 8 inches

Typical Profile of the Yapoah Soil

2 inches to 0—organic mat
0 to 12 inches—dark brown very cobbly loamy sand
12 to 60 inches—dark yellowish brown extremely flaggy loamy sand

Properties and Qualities of the Yapoah Soil

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Rapid
Available water capacity: About 2 inches

Contrasting Inclusions

- Fryrear soils on side slopes and ridges
- Wanoga soils on side slopes
- Rock outcrop

Major Use

Woodland

Major Management Limitations

Sisters soil—slope, low fertility, susceptibility to compaction
Yapoah soil—slope, rock fragments, available water capacity

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Wheeled and tracked equipment can be used; however, cable yarding generally is safer and disturbs the soil less.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil in the Sisters soil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility of the Sisters soil to compaction, designated skid trails should be used.
- Seedlings on the Yapoah soil have a poor survival rate because of the low available water capacity.
- Rock fragments in the Yapoah soil restrict the planting of seedlings.

Forest Service Plant Association

CP-S2-17

123E—Sisters-Yapoah complex, 30 to 50 percent slopes

Composition

Sisters soil and similar inclusions—50 percent
Yapoah soil and similar inclusions—35 percent
Contrasting inclusions—15 percent

Setting

Landform: Mountains
Parent material: Sisters soil—ash over colluvium and residuum; Yapoah soil—ash and colluvium
Elevation: 3,200 to 5,000 feet
Native plants: Ponderosa pine, antelope bitterbrush, greenleaf manzanita, Idaho fescue
Climatic factors:
Mean annual precipitation—18 to 30 inches
Mean annual air temperature—40 to 47 degrees F
Frost-free period—50 to 90 days

Typical Profile of the Sisters Soil

2 inches to 0—organic mat
0 to 23 inches—dark brown and dark yellowish brown loamy sand
23 to 35 inches—dark brown sandy loam
35 to 60 inches—dark reddish brown and dark brown clay loam and loam

Properties and Qualities of the Sisters Soil

Depth: Colluvium at a depth of 20 to 35 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Rapid over moderately slow
Available water capacity: About 8 inches

Typical Profile of the Yapoah Soil

2 inches to 0—organic mat
0 to 12 inches—dark brown very cobbly loamy sand

12 to 60 inches—dark yellowish brown extremely flaggy loamy sand

Properties and Qualities of the Yapoah Soil

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Rapid
Available water capacity: About 2 inches

Contrasting Inclusions

- Fryrear soils on side slopes and ridges
- Wanoga soils on side slopes
- Rock outcrop

Major Use

Woodland

Major Management Limitations

Sisters soil—slope, low fertility, susceptibility to compaction
Yapoah soil—slope, rock fragments, available water capacity

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the susceptibility to compaction, all ground operations, including tractor skidding, mechanical harvesting, and machine piling, should be avoided unless the surface layer is frozen or covered with snow. Subsoiling can be used to loosen the compacted layer.
- Because of the moderate susceptibility of the Sisters soil to compaction, designated skid trails should be used.
- Seedlings on the Yapoah soil have a poor survival rate because of the low available water capacity.
- Rock fragments in the Yapoah soil restrict the planting of seedlings.

Forest Service Plant Association

CP-S2-17

124C—Smiling sandy loam, 0 to 15 percent slopes

Composition

Smiling soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landform: Mountains
Parent material: Ash over colluvium
Elevation: 2,500 to 3,500 feet
Native plants: Ponderosa pine, antelope bitterbrush, greenleaf manzanita, Idaho fescue
Climatic factors:
Mean annual precipitation—20 to 40 inches
Mean annual air temperature—42 to 47 degrees F
Frost-free period—60 to 90 days

Typical Profile

1 inch to 0—organic mat
0 to 16 inches—very dark brown and dark brown sandy loam
16 to 39 inches—dark brown loam
39 to 63 inches—dark brown clay loam

Soil Properties and Qualities

Depth: Colluvium at a depth of 14 to 33 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 10 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 40 to 60 inches
- Windego soils on side slopes

Major Use

Woodland

Major Management Limitations

Low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.

- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CP-S2-17

125D—Smiling-Windego complex, 15 to 30 percent slopes

Composition

Smiling soil and similar inclusions—50 percent
Windego soil and similar inclusions—35 percent
Contrasting inclusions—15 percent

Setting

Landform: Mountains
Parent material: Ash over colluvium
Elevation: 2,500 to 3,500 feet
Native plants: Smiling soil—ponderosa pine, antelope bitterbrush, greenleaf manzanita, Idaho fescue; Windego soil—ponderosa pine, antelope bitterbrush, greenleaf manzanita, needlegrasses
Climatic factors:
Mean annual precipitation—20 to 40 inches
Mean annual air temperature—42 to 47 degrees F
Frost-free period—60 to 90 days

Typical Profile of the Smiling Soil

1 inch to 0—organic mat
0 to 16 inches—very dark brown and dark brown sandy loam
16 to 39 inches—dark brown loam
39 to 63 inches—dark brown clay loam

Properties and Qualities of the Smiling Soil

Depth: Colluvium at a depth of 14 to 33 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 10 inches

Typical Profile of the Windego Soil

1 inch to 0—organic mat
0 to 19 inches—dark brown and brown sandy loam
19 to 30 inches—brown very cobbly loam
30 to 60 inches—brown and yellowish brown very cobbly clay loam

Properties and Qualities of the Windego Soil

Depth: Colluvium at a depth of 14 to 25 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 6 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 20 to 40 inches
- Rock outcrop on ridges

Major Use

Woodland

Major Management Limitations

Slope, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Wheeled and tracked equipment can be used; however, cable yarding generally is safer and disturbs the soil less.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

Smiling soil—CP-S2-17
Windego soil—CP-S2-13

126C—Smiling-Windego complex, cool, 0 to 15 percent slopes

Composition

Smiling soil and similar inclusions—65 percent
Windego soil and similar inclusions—25 percent
Contrasting inclusions—10 percent

Setting

Landform: Mountains
Parent material: Ash over colluvium
Elevation: 3,500 to 4,000 feet
Native plants: Ponderosa pine, Douglas fir, snowbrush, chinkapin, brackenfern
Climatic factors:
Mean annual precipitation—30 to 50 inches
Mean annual air temperature—40 to 45 degrees F
Frost-free period—50 to 70 days

Typical Profile of the Smiling Soil

1 inch to 0—organic mat
0 to 16 inches—very dark brown and dark brown sandy loam
16 to 39 inches—dark brown loam
39 to 63 inches—dark brown clay loam

Properties and Qualities of the Smiling Soil

Depth: Colluvium at a depth of 14 to 33 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 10 inches

Typical Profile of the Windego Soil

1 inch to 0—organic mat
0 to 19 inches—dark brown and brown sandy loam
19 to 30 inches—brown very cobbly loam
30 to 60 inches—brown and yellowish brown very cobbly clay loam

Properties and Qualities of the Windego Soil

Depth: Colluvium at a depth of 14 to 25 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 6 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 20 to 40 inches
- Rock outcrop on ridges
- Bott soils on ridges

Major Use

Woodland

Major Management Limitations

Low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CW-C2-11

126D—Smiling-Windego complex, cool, 15 to 30 percent slopes

Composition

Smiling soil and similar inclusions—65 percent
Windego soil and similar inclusions—25 percent
Contrasting inclusions—10 percent

Setting

Landform: Mountains
Parent material: Ash over colluvium
Elevation: 3,500 to 4,000 feet
Native plants: Ponderosa pine, Douglas fir, snowbrush, chinkapin, brackenfern
Climatic factors:
Mean annual precipitation—30 to 50 inches
Mean annual air temperature—40 to 45 degrees F
Frost-free period—50 to 70 days

Typical Profile of the Smiling Soil

1 inch to 0—organic mat
0 to 16 inches—very dark brown and dark brown sandy loam
16 to 39 inches—dark brown loam
39 to 63 inches—dark brown clay loam

Properties and Qualities of the Smiling Soil

Depth: Colluvium at a depth of 14 to 33 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 10 inches

Typical Profile of the Windego Soil

1 inch to 0—organic mat
0 to 19 inches—dark brown and brown sandy loam
19 to 30 inches—brown very cobbly loam
30 to 60 inches—dark brown and yellowish brown very cobbly clay loam

Properties and Qualities of the Windego Soil

Depth: Colluvium at a depth of 14 to 25 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained

Permeability: Moderate
Available water capacity: About 6 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 20 to 40 inches
- Rock outcrop on ridges
- Bott soils on ridges

Major Use

Woodland

Major Management Limitations

Slope, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Wheeled and tracked equipment can be used; however, cable yarding generally is safer and disturbs the soil less.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CW-C2-11

127A—Statz sandy loam, 0 to 3 percent slopes

Composition

Statz soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 2,000 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—70 to 100 days

Typical Profile

0 to 14 inches—grayish brown sandy loam
14 to 20 inches—brown sandy loam
20 to 25 inches—indurated duripan
25 inches—basalt

Soil Properties and Qualities

Depth: Duripan at a depth of 10 to 20 inches; bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Contrasting Inclusions

- Houstake, Deschutes, and Redmond soils in swales
- Rock outcrop

Major Uses

Livestock grazing, irrigated cropland

Major Management Limitations

Surface texture, soil depth, permeability, available water capacity

General Management Considerations

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and risk of seepage.
- The restricted soil depth limits the choice of species for range seeding to drought-tolerant varieties.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Irrigated cropland

- Because of the restricted soil depth and the low available water capacity, intensive irrigation water management is needed for crop production.
- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.

- The included areas of Rock outcrop limit the areas suitable for crops and restrict farming operations.

Range Site

Lava Blisters 10-12pz

128C—Statz-Deschutes complex, 0 to 15 percent slopes

Composition

Statz soil and similar inclusions—45 percent
Deschutes soil and similar inclusions—40 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 2,500 to 4,000 feet
Native plants: Statz soil—western juniper, mountain big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue; Deschutes soil—western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—70 to 90 days

Typical Profile of the Statz Soil

0 to 14 inches—grayish brown sandy loam
14 to 20 inches—brown sandy loam
20 to 25 inches—indurated duripan
25 inches—basalt

Properties and Qualities of the Statz Soil

Depth: Duripan at a depth of 10 to 20 inches; bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 2 inches

Typical Profile of the Deschutes Soil

0 to 17 inches—grayish brown sandy loam
17 to 31 inches—light grayish brown sandy loam
31 inches—basalt

Properties and Qualities of the Deschutes Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 4 inches

Contrasting Inclusions

- Redmond soils in swales
- Stukel soils on ridges

Major Use

Livestock grazing

Major Management Limitations

Statz and Deschutes soils—surface texture, soil depth
Deschutes soil—permeability

General Management Considerations

- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth, the risk of seepage in the Deschutes soil, and the steepness of slope in some areas.
- The restricted depth of the Statz soil limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Statz soil—Lava Blisters 10-12pz
Deschutes soil—Pumice Flat 10-12pz

128D—Statz-Deschutes complex, 15 to 30 percent slopes

Composition

Statz soil and similar inclusions—45 percent
Deschutes soil and similar inclusions—40 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 2,500 to 4,000 feet
Native plants: Statz soil—western juniper, mountain big sagebrush, bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass; Deschutes soil—western juniper, antelope bitterbrush, mountain big sagebrush, Idaho fescue, bluebunch wheatgrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—70 to 90 days

Typical Profile of the Statz Soil

0 to 14 inches—grayish brown sandy loam

14 to 20 inches—brown sandy loam
20 to 25 inches—indurated duripan
25 inches—basalt

Properties and Qualities of the Statz Soil

Depth: Duripan at a depth of 10 to 20 inches; bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Typical Profile of the Deschutes Soil

0 to 17 inches—grayish brown sandy loam
17 to 31 inches—light grayish brown sandy loam
31 inches—basalt

Properties and Qualities of the Deschutes Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 4 inches

Contrasting Inclusions

- Redmond soils in swales
- Stukel soils on ridges

Major Use

Livestock grazing

Major Management Limitations

Statz and Deschutes soils—surface texture, soil depth
Deschutes soil—permeability

General Management Considerations

- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth, the risk of seepage in the Deschutes soil, and the steepness of slope.
- The restricted depth of the Statz soil limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Statz soil—Shallow North 9-12pz
Deschutes soil—Sandy North 9-14pz

129C—Steiger loamy coarse sand, 0 to 15 percent slopes

Composition

Steiger soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Pumice-mantled lava plains
Parent material: Ash and pumice over colluvium and old alluvium
Elevation: 4,200 to 4,500 feet
Native plants: Ponderosa pine, antelope bitterbrush, needlegrasses
Climatic factors:
Mean annual precipitation—18 to 25 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—20 to 50 days

Typical Profile

3 inches to 0—organic mat
0 to 2 inches—dark grayish brown loamy coarse sand
2 to 18 inches—dark brown gravelly coarse sand
18 to 28 inches—light brownish gray very gravelly coarse sand
28 to 49 inches—pale yellow gravelly coarse sand
49 to 60 inches—dark yellowish brown loam

Soil Properties and Qualities

Depth: Colluvium at a depth of 40 to 60 inches; bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Rapid over moderate
Available water capacity: About 11 inches

Contrasting Inclusions

- Shanahan soils north of LaPine
- Tutni soils in depressions
- Poorly drained soils in depressions

Major Use

Woodland

Major Management Limitations

Soil depth, soil texture, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.

- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because this coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CP-S2-12

130C—Steiger loamy coarse sand, high elevation, 3 to 15 percent slopes

Composition

Steiger soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Pumice-mantled lava plains
Parent material: Ash and pumice over colluvium and old alluvium
Elevation: 4,500 to 6,000 feet
Native plants: Ponderosa pine, white fir, Douglas fir, snowbrush, manzanita
Climatic factors:
Mean annual precipitation—18 to 25 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—10 to 40 days

Typical Profile

3 inches to 0—organic mat
0 to 2 inches—dark grayish brown loamy coarse sand
2 to 18 inches—dark brown gravelly coarse sand
18 to 28 inches—light brownish gray very gravelly coarse sand
28 to 49 inches—pale yellow gravelly coarse sand
49 to 60 inches—dark yellowish brown loam

Soil Properties and Qualities

Depth: Colluvium at a depth of 40 to 60 inches; bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Rapid over moderate
Available water capacity: About 11 inches

Contrasting Inclusions

- Shanahan soils north of LaPine

Major Use

Woodland

Major Management Limitations

Soil depth, soil texture, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because this coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CW-S1-12

130D—Steiger loamy coarse sand, high elevation, 15 to 30 percent slopes

Composition

Steiger soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Pumice-mantled hills
Parent material: Ash and pumice over colluvium
Elevation: 4,500 to 6,000 feet
Native plants: Ponderosa pine, white fir, Douglas fir, snowbrush, manzanita
Climatic factors:
Mean annual precipitation—18 to 25 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—10 to 40 days

Typical Profile

3 inches to 0—organic mat
0 to 2 inches—dark grayish brown loamy coarse sand

2 to 18 inches—dark brown gravelly coarse sand
18 to 28 inches—light brownish gray very gravelly coarse sand
28 to 49 inches—pale yellow gravelly coarse sand
49 to 60 inches—dark yellowish brown loam

Soil Properties and Qualities

Depth: Colluvium at a depth of 40 to 60 inches; bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Rapid over moderate
Available water capacity: About 11 inches

Contrasting Inclusions

- Shanahan soils north of LaPine

Major Use

Woodland

Major Management Limitations

Soil depth, slope, soil texture, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because this coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- Wheeled and tracked equipment can be used; however, cable yarding generally is safer and disturbs the soil less.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Using machinery only in areas covered with logging slash or brush reduces soil displacement.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CW-S1-12

130E—Steiger loamy coarse sand, high elevation, 30 to 50 percent slopes

Composition

Steiger soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Pumice-mantled hills
Parent material: Ash and pumice over colluvium
Elevation: 4,500 to 6,000 feet
Native plants: Ponderosa pine, white fir, Douglas fir, snowbrush, manzanita
Climatic factors:
Mean annual precipitation—18 to 25 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—10 to 40 days

Typical Profile

3 inches to 0—organic mat
0 to 2 inches—dark grayish brown loamy coarse sand
2 to 18 inches—dark brown gravelly coarse sand
18 to 28 inches—light brownish gray very gravelly coarse sand
28 to 49 inches—pale yellow gravelly coarse sand
49 to 60 inches—dark yellowish brown loam

Soil Properties and Qualities

Depth: Colluvium at a depth of 40 to 60 inches; bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Rapid over moderate
Available water capacity: About 11 inches

Contrasting Inclusions

- Shanahan soils north of LaPine

Major Use

Woodland

Major Management Limitations

Soil depth, slope, soil texture, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical

treatment, chemical treatment, or livestock grazing.
- Because this coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Restrict the use of prescribed burning to periods when logging slash or natural fuel has a moderate to high moisture content or consider alternative disposal techniques.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Using machinery only in areas covered with logging slash or brush reduces soil displacement.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CW-S1-12

131A—Steiger loamy coarse sand, low, 0 to 3 percent slopes

Composition

Steiger soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landscape position: Depressions
Landform: Pumice-mantled lava plains
Parent material: Ash and pumice over old alluvium and colluvium
Elevation: 4,200 to 4,500 feet
Native plants: Lodgepole pine, antelope bitterbrush, Idaho fescue
Climatic factors:
Mean annual precipitation—18 to 25 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—10 to 30 days

Typical Profile

3 inches to 0—organic mat
0 to 2 inches—dark grayish brown loamy coarse sand
2 to 18 inches—dark brown gravelly coarse sand
18 to 28 inches—light brownish gray very gravelly coarse sand
28 to 49 inches—pale yellow gravelly coarse sand
49 to 60 inches—dark yellowish brown loam

Soil Properties and Qualities

Depth: Old alluvium at a depth of 40 to 60 inches; bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Rapid over moderate
Available water capacity: About 11 inches

Contrasting Inclusions

- Shanahan soils north of LaPine
- Tutni soils in depressions
- Poorly drained soils in depressions

Major Use

Woodland

Major Management Limitations

Frost heaving, soil depth, soil texture, low fertility, susceptibility to compaction

General Management Considerations

- Severe frost or frost heaving can damage or kill seedlings.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because this coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CL-S2-14

132A—Stookmoor loamy sand, 1 to 3 percent slopes

Composition

Stookmoor soil and similar inclusions—85 percent

Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 4,300 to 4,800 feet
Native plants: Mountain big sagebrush, Idaho fescue, Thurber needlegrass, western needlegrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 6 inches—grayish brown loamy sand
6 to 24 inches—grayish brown and pale brown sandy loam
24 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Somewhat excessively drained
Permeability: Rapid over moderately slow
Available water capacity: About 4 inches

Contrasting Inclusions

- Ninemile and Dester soils on lava plains
- Choptie soils on knolls
- Gardone soils on toe slopes
- Borobey soils along drainageways

Major Use

Livestock grazing

Major Management Limitations

Climate, surface texture, soil depth, permeability

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and risk of seepage.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Pumice 8-10pz

133A—Stookmoor gravelly loamy sand, 1 to 3 percent slopes

Composition

Stookmoor soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 4,300 to 4,800 feet
Native plants: Mountain big sagebrush, western needlegrass, Ross sedge, bottlebrush squirreltail
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 6 inches—grayish brown gravelly loamy sand
6 to 24 inches—grayish brown and pale brown sandy loam
24 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Somewhat excessively drained
Permeability: Rapid over moderately slow
Available water capacity: About 4 inches

Contrasting Inclusions

- Ninemile and Dester soils on lava plains
- Choptie soils on knolls
- Gardone soils toe slopes
- Borobey soils along drainageways

Major Use

Livestock grazing

Major Management Limitations

Climate, surface texture, soil depth, permeability

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and risk of seepage.

- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.

Range Site

Pumice Flat 9-11pz

134D—Stookmoor gravelly loamy sand, 20 to 50 percent north slopes

Composition

Stookmoor soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landscape position: Side slopes
Landform: Hills
Parent material: Ash
Elevation: 4,300 to 4,800 feet
Native plants: Western juniper, mountain big sagebrush, Idaho fescue, bluebunch wheatgrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 6 inches—grayish brown gravelly loamy sand
6 to 24 inches—grayish brown and pale brown sandy loam
24 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Somewhat excessively drained
Permeability: Rapid over moderately slow
Available water capacity: About 4 inches

Contrasting Inclusions

- Choptie soils on knolls and hills
- Gardone soils on toe slopes
- Westbutte soils on steep hillsides
- Redcliff soils along drainageways of rocky ravines

Major Use

Livestock grazing

Major Management Limitations

Climate, surface texture, soil depth, permeability, slope

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth, risk of seepage, and steepness of slope.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.
- The steepness of slope restricts livestock distribution and limits range seeding with ground equipment.

Range Site

Pumice North 9-12pz

135C—Stookmoor-Beden complex, 1 to 20 percent slopes

Composition

Stookmoor soil and similar inclusions—45 percent
Beden soil and similar inclusions—40 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Stookmoor soil—ash; Beden soil—residuum derived from basalt with ash on the surface
Elevation: 4,300 to 4,800 feet
Native plants: Stookmoor soil—mountain big sagebrush, Idaho fescue, Thurber needlegrass, western needlegrass; Beden soil—western juniper, mountain big sagebrush, Idaho fescue, Thurber needlegrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile of the Stookmoor Soil

0 to 6 inches—grayish brown loamy sand
6 to 24 inches—grayish brown and pale brown sandy loam
24 inches—basalt

Properties and Qualities of the Stookmoor Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Somewhat excessively drained
Permeability: Rapid over moderately slow
Available water capacity: About 4 inches

Typical Profile of the Beden Soil

0 to 11 inches—grayish brown and brown sandy loam
11 to 15 inches—brown loam
15 to 18 inches—brown clay loam
18 inches—basalt

Properties and Qualities of the Beden Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 3 inches

Contrasting Inclusions

- Borobey soils in small basins and along narrow drainageways
- Gardone soils on toe slopes
- Dester soils on lava plains
- Rock outcrop on basalt pressure ridges

Major Use

Livestock grazing

Major Management Limitations

Climate, surface texture, soil depth

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and by the steepness of slope in some areas.
- The low annual precipitation and the restricted depth of the Beden soil limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Stookmoor soil—Pumice 8-10pz
Beden soil—Shallow Pumice Hills 9-11pz

136C—Stookmoor-Gardone-Rock outcrop complex, 1 to 15 percent slopes

Composition

Stookmoor soil and similar inclusions—45 percent
Gardone soil and similar inclusions—35 percent
Rock outcrop—10 percent
Contrasting inclusions—10 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 4,300 to 4,800 feet
Native plants: Mountain big sagebrush, Idaho fescue, Thurber needlegrass, western needlegrass
Climatic factors:
  Mean annual precipitation—10 to 12 inches
  Mean annual air temperature—43 to 45 degrees F
  Frost-free period—50 to 90 days

Typical Profile of the Stookmoor Soil

0 to 6 inches—grayish brown loamy sand
6 to 24 inches—grayish brown and pale brown sandy loam
24 inches—basalt

Properties and Qualities of the Stookmoor Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Somewhat excessively drained
Permeability: Rapid over moderately slow
Available water capacity: About 4 inches

Typical Profile of the Gardone Soil

0 to 10 inches—dark grayish brown sand
10 to 60 inches—grayish brown and pale brown loamy sand

Properties and Qualities of the Gardone Soil

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Excessively drained
Permeability: Rapid
Available water capacity: About 6 inches

Contrasting Inclusions

- Borobey soils in small basins and along narrow drainageways

- Moderately deep and deep ash deposits over a buried soil
- Blayden soils on terraces

Major Use

Livestock grazing

Major Management Limitations

Rock outcrop, climate, surface texture, soil depth, permeability

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth, the risk of seepage, and the steepness of slope in some areas.
- The low annual precipitation limits the choice of species for range seeding to drought-tolerant varieties.
- The areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Pumice 8-10pz

137E—Stookmoor-Westbutte complex, 25 to 50 percent north slopes

Composition

Stookmoor soil and similar inclusions—45 percent
Westbutte soil and similar inclusions—40 percent
Contrasting inclusions—15 percent

Setting

Landscape position: North-facing slopes
Landform: Hills
Parent material: Stookmoor soil—ash; Westbutte soil—colluvium derived from basalt or tuff with ash on the surface
Elevation: 4,300 to 4,800 feet
Native plants: Western juniper, mountain big sagebrush, Idaho fescue, bluebunch wheatgrass
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile of the Stookmoor Soil

0 to 6 inches—grayish brown loamy sand
6 to 24 inches—grayish brown and pale brown sandy loam
24 inches—basalt

Properties and Qualities of the Stookmoor Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Somewhat excessively drained
Permeability: Rapid over moderately slow
Available water capacity: About 4 inches

Typical Profile of the Westbutte Soil

0 to 9 inches—very dark grayish brown stony loam
9 to 21 inches—dark brown very cobbly loam
21 to 30 inches—brown very cobbly clay loam
30 inches—welded tuff

Properties and Qualities of the Westbutte Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 4 inches

Contrasting Inclusions

- Menbo soils on ridges
- Choptie soils near areas of Rock outcrop
- Rock outcrop that occurs as ridges of basalt or welded tuff
- Gardone soils

Major Use

Livestock grazing

Major Management Limitations

Climate, surface texture, soil depth, permeability, rock fragments in surface layer, slope

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the Stookmoor soil from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth, risk of seepage, and steepness of slope.
- The low annual precipitation and the restricted soil depth limit productivity and limit the choice of species

for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface of the Westbutte soil.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.
- The steepness of slope restricts livestock distribution and limits range seeding with ground equipment.

Range Site

Pumice North 9-12pz

138A—Stukel sandy loam, 0 to 3 percent slopes

Composition

Stukel soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 2,500 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
  Mean annual precipitation—10 to 12 inches
  Mean annual air temperature—47 to 50 degrees F
  Frost-free period—70 to 90 days

Typical Profile

0 to 4 inches—grayish brown sandy loam
4 to 11 inches—brown cobbly sandy loam
11 to 18 inches—pale brown gravelly sandy loam
18 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Contrasting Inclusions

- Deschutes and Houstake soils in swales
- Soils that have a loamy sand surface layer
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Surface texture, soil depth

General Management Considerations

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth.
- The restricted soil depth limits the choice of species for range seeding to drought-tolerant varieties.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Lava Blisters 10-12pz

138B—Stukel sandy loam, 3 to 8 percent slopes

Composition

Stukel soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 2,500 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue
Climatic factors:
  Mean annual precipitation—10 to 12 inches
  Mean annual air temperature—47 to 50 degrees F
  Frost-free period—70 to 90 days

Typical Profile

0 to 4 inches—grayish brown sandy loam
4 to 11 inches—brown cobbly sandy loam
11 to 18 inches—pale brown gravelly sandy loam
18 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Contrasting Inclusions

- Deschutes and Houstake soils in swales

- Soils that have a loamy sand surface layer
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Surface texture, soil depth

General Management Considerations

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth.
- The restricted soil depth limits the choice of species for range seeding to drought-tolerant varieties.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Lava Blisters 10-12pz

139A—Stukel sandy loam, dry, 0 to 3 percent slopes

Composition

Stukel soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 2,500 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, bluebunch wheatgrass, Thurber needlegrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—8 to 10 inches
Mean annual air temperature—49 to 52 degrees F
Frost-free period—80 to 100 days

Typical Profile

0 to 4 inches—grayish brown sandy loam
4 to 11 inches—brown cobbly sandy loam
11 to 18 inches—pale brown gravelly sandy loam
18 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Contrasting Inclusions

- Deschutes and Houstake soils in swales
- Soils that have a loamy sand surface layer
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Surface texture, soil depth, climate

General Management Considerations

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth.
- The low annual precipitation and restricted soil depth limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Lava Blisters 8-10pz

139B—Stukel sandy loam, dry, 3 to 8 percent slopes

Composition

Stukel soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 2,500 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, bluebunch wheatgrass, Thurber needlegrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—8 to 10 inches
Mean annual air temperature—49 to 52 degrees F
Frost-free period—80 to 100 days

Typical Profile

0 to 4 inches—grayish brown sandy loam
4 to 11 inches—brown cobbly sandy loam

11 to 18 inches—pale brown gravelly sandy loam
18 inches—basalt

Soil Properties and Qualities

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Contrasting Inclusions

- Deschutes and Houstake soils in swales
- Soils that have a loamy sand surface layer
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Surface texture, soil depth, climate

General Management Considerations

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth.
- The low annual precipitation and restricted soil depth limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Lava Blisters 8-10pz

140B—Stukel-Deschutes complex, dry, 0 to 8 percent slopes

Composition

Stukel soil and similar inclusions—50 percent
Deschutes soil and similar inclusions—35 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 2,500 to 4,000 feet
Native plants: Stukel soil—western juniper, mountain big sagebrush, needleandthread, Idaho fescue, western needlegrass; Deschutes soil—western juniper, mountain big sagebrush, bluebunch wheatgrass, Thurber needlegrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—8 to 10 inches
Mean annual air temperature—49 to 52 degrees F
Frost-free period—80 to 100 days

Typical Profile of the Stukel Soil

0 to 4 inches—grayish brown sandy loam
4 to 11 inches—brown cobbly sandy loam
11 to 18 inches—pale brown gravelly sandy loam
18 inches—basalt

Properties and Qualities of the Stukel Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Typical Profile of the Deschutes Soil

0 to 17 inches—grayish brown sandy loam
17 to 31 inches—light grayish brown sandy loam
31 inches—basalt

Properties and Qualities of the Deschutes Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 4 inches

Contrasting Inclusions

- Redmond soils in swales
- Soils that have a loamy sand surface layer
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Surface texture, soil depth, permeability, climate

General Management Considerations

- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development on these soils is limited by the soil depth and risk of seepage.
- The low annual precipitation and restricted depth of the Stukel soil limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- The included areas of Rock outcrop limit the areas

suitable for grazing and restrict accessibility by livestock.

Range Site

Stukel soil—Lava Blisters 8-10pz
Deschutes soil—Pumice Flat 8-10pz

141C—Stukel-Deschutes-Rock outcrop complex, 0 to 15 percent slopes

Composition

Stukel soil and similar inclusions—40 percent
Deschutes soil and similar inclusions—25 percent
Rock outcrop—20 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 2,500 to 4,000 feet
Native plants: Stukel soil—western juniper, mountain big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue; Deschutes soil—western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 50 degrees F
Frost-free period—70 to 90 days

Typical Profile of the Stukel Soil

0 to 4 inches—grayish brown sandy loam
4 to 11 inches—brown cobbly sandy loam
11 to 18 inches—pale brown gravelly sandy loam
18 inches—basalt

Properties and Qualities of the Stukel Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Typical Profile of the Deschutes Soil

0 to 17 inches—grayish brown sandy loam
17 to 31 inches—light grayish brown sandy loam
31 inches—basalt

Properties and Qualities of the Deschutes Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 4 inches

Contrasting Inclusions

- Redmond soils in swales

Major Use

Livestock grazing

Major Management Limitations

Rock outcrop, surface texture, soil depth, permeability

General Management Considerations

- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth, the risk of seepage, and the steepness of slope in some areas.
- The restricted depth of the Stukel soil limits the choice of species for range seeding to drought-tolerant varieties.
- The areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Stukel soil—Lava Blisters 10-12pz
Deschutes soil—Pumice Flat 10-12pz

142B—Stukel-Rock outcrop-Deschutes complex, dry, 0 to 8 percent slopes

Composition

Stukel soil and similar inclusions—35 percent
Rock outcrop—30 percent
Deschutes soil and similar inclusions—20 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash
Elevation: 2,500 to 3,500 feet
Native plants: Stukel soil—western juniper, mountain big sagebrush, bluebunch wheatgrass, Thurber needlegrass, Sandberg bluegrass; Deschutes soil—western juniper, mountain big sagebrush, needleandthread, Idaho fescue, western needlegrass
Climatic factors:

Mean annual precipitation—8 to 10 inches
Mean annual air temperature—49 to 52 degrees F
Frost-free period—80 to 100 days

Typical Profile of the Stukel Soil

0 to 4 inches—grayish brown sandy loam
4 to 11 inches—brown cobbly sandy loam
11 to 18 inches—pale brown gravelly sandy loam
18 inches—basalt

Properties and Qualities of the Stukel Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Typical Profile of the Deschutes Soil

0 to 17 inches—grayish brown sandy loam
17 to 31 inches—light grayish brown sandy loam
31 inches—basalt

Properties and Qualities of the Deschutes Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 4 inches

Contrasting Inclusions

- Redmond and Houstake soils in swales

Major Use

Livestock grazing

Major Management Limitations

Rock outcrop, surface texture, soil depth, permeability, climate

General Management Considerations

- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and risk of seepage.
- The low annual precipitation and the restricted depth of the Stukel soil limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- The areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Stukel soil—Lava Blisters 8-10pz
Deschutes soil—Pumice Flat 8-10pz

143B—Suilotem-Circle complex, 0 to 8 percent slopes

Composition

Suilotem soil and similar inclusions—50 percent
Circle soil and similar inclusions—35 percent
Contrasting inclusions—15 percent

Setting

Landform: Outwash plains
Parent material: Ash over glacial outwash
Elevation: 2,500 to 3,500 feet
Native plants: Suilotem soil—ponderosa pine, white fir, common snowberry, twinflower; Circle soil—ponderosa pine, antelope bitterbrush, greenleaf manzanita, Idaho fescue
Climatic factors:
Mean annual precipitation—20 to 35 inches
Mean annual air temperature—40 to 47 degrees F
Frost-free period—50 to 90 days

Typical Profile of the Suilotem Soil

1 inch to 0—organic mat
0 to 27 inches—dark brown sandy loam
27 to 51 inches—very dark brown and black fine sandy loam and loamy fine sand
51 to 60 inches—dark brown very fine sandy loam

Properties and Qualities of the Suilotem Soil

Depth: Glacial outwash at a depth of 40 to 60 inches; bedrock at a depth of 60 inches or more
Drainage class: Somewhat poorly drained
Depth to water table: At the surface to a depth of 24 inches below the surface in April through June
Permeability: Moderately rapid
Available water capacity: About 8 inches

Typical Profile of the Circle Soil

1 inch to 0—organic mat
0 to 16 inches—dark brown sandy loam
16 to 42 inches—dark brown and dark yellowish brown loam and gravelly loam
42 to 65 inches—dark yellowish brown very gravelly clay loam

Properties and Qualities of the Circle Soil

Depth: Glacial outwash at a depth of 40 to 50 inches;

bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 9 inches

Contrasting Inclusions

- Allingham soils in higher positions
- Suttle and Wizard soils in swales
- Poorly drained soils in swales

Major Use

Woodland

Major Management Limitations

Suilotem and Circle soils—low fertility, susceptibility to compaction
Suilotem soil—wetness

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- The seasonal high water table in the Suilotem soil restricts the use of equipment to midsummer when the soil is dry or to midwinter when the soil is frozen.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

Suilotem soil—CD-S6-12
Circle soil—CP-S2-17

144A—Sunriver sandy loam, 0 to 3 percent slopes

Composition

Sunriver soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Stream terraces
Parent material: Ash over old alluvium
Elevation: 4,000 to 4,300 feet
Native plants: Lodgepole pine, blueberry, forbs
Climatic factors:
  Mean annual precipitation—18 to 25 inches
  Mean annual air temperature—40 to 44 degrees F
  Frost-free period—10 to 50 days

Typical Profile

2 inches to 0—organic mat
0 to 5 inches—very dark gray sandy loam
5 to 20 inches—dark gray loamy coarse sand
20 to 29 inches—light brownish gray coarse sand
29 to 60 inches—very dark gray sandy loam

Soil Properties and Qualities

Depth: Old alluvium at a depth of 25 to 35 inches; bedrock at a depth of 60 inches or more
Drainage class: Somewhat poorly drained
Depth to water table: 24 to 48 inches below the surface in April through June
Permeability: Moderately rapid
Available water capacity: About 7 inches

Contrasting Inclusions

- Cryaquolls adjacent to streams and rivers
- Well drained and moderately well drained soils in slightly higher areas

Major Use

Woodland

Major Management Limitations

Soil depth, wetness, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because this coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- The seasonal high water table restricts the use of equipment to midsummer when the soil is dry or to midwinter when the soil is frozen.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CL-M3-11

145C—Suttle very gravelly loamy sand, 0 to 15 percent slopes

Composition

Suttle soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Outwash plains
Parent material: Ash and scoria over glacial outwash
Elevation: 3,000 to 3,500 feet
Native plants: Ponderosa pine, white fir, common snowberry, twinflower
Climatic factors:
  Mean annual precipitation—30 to 40 inches
  Mean annual air temperature—40 to 47 degrees F
  Frost-free period—50 to 90 days

Typical Profile

1 inch to 0—organic mat
0 to 10 inches—black very gravelly loamy sand
10 to 22 inches—black and dark brown very gravelly coarse sand
22 to 37 inches—dark brown and black gravelly sandy loam and loamy fine sand
37 to 60 inches—dark brown sandy loam

Soil Properties and Qualities

Depth: Glacial outwash at a depth of 20 to 30 inches; bedrock at a depth of 60 inches or more
Drainage class: Somewhat poorly drained
Depth to water table: At the surface to a depth of 24 inches below the surface in April through June
Permeability: Very rapid over moderately rapid
Available water capacity: About 5 inches

Contrasting Inclusions

- Allingham and Circle soils on outwash plains in slightly higher positions
- Suilotem soils in swales and channels
- Poorly drained soils in swales

Major Use

Woodland

Major Management Limitation

Surface texture

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Because the surface layer is coarse textured, the available water capacity is low and the seedling mortality rate is severe.

Forest Service Plant Association

CD-S6-12

146C—Suttle very gravelly loamy sand, dry, 0 to 15 percent slopes

Composition

Suttle soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Outwash plains
Parent material: Ash and scoria over glacial outwash
Elevation: 2,500 to 3,000 feet
Native plants: Ponderosa pine, antelope bitterbrush, greenleaf manzanita, Idaho fescue
Climatic factors:
  Mean annual precipitation—20 to 30 inches
  Mean annual air temperature—40 to 47 degrees F
  Frost-free period—50 to 90 days

Typical Profile

1 inch to 0—organic mat
0 to 10 inches—black very gravelly loamy sand
10 to 22 inches—black and dark brown very gravelly coarse sand
22 to 37 inches—dark brown and black gravelly sandy loam and loamy fine sand
37 to 60 inches—dark brown sandy loam

Soil Properties and Qualities

Depth: Glacial outwash at a depth of 20 to 30 inches; bedrock at a depth of 60 inches or more
Drainage class: Somewhat poorly drained
Depth to water table: At the surface to a depth of 24 inches below the surface in April through June
Permeability: Very rapid over moderately rapid
Available water capacity: About 5 inches

Contrasting Inclusions

- Allingham and Circle soils on outwash plains in slightly higher positions
- Suilotem soils in swales and channels

Major Use

Woodland

Major Management Limitation

Surface texture

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Because the surface layer is coarse textured, the available water capacity is low and the seedling mortality rate is severe.

Forest Service Plant Association

CP-S2-17

147A—Swaler gravelly coarse sand, 0 to 2 percent slopes

Composition

Swaler soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lake terraces
Parent material: Lacustrine sediment with ash on the surface
Elevation: 4,100 to 4,600 feet
Native plants: Mountain big sagebrush, western needlegrass, Ross sedge, bottlebrush squirreltail
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 7 inches—light gray and light brownish gray gravelly coarse sand
7 to 10 inches—light gray silt loam
10 to 26 inches—brown and pale brown clay and silty clay loam
26 to 60 inches—pale brown silty clay loam

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Moderately well drained
Ponding: 12 inches above the surface to a depth of 12 inches below the surface in March through May
Permeability: Very slow
Available water capacity: About 8 inches

Contrasting Inclusions

- Dester soils near terrace escarpments
- Ninemile soils on lava plains
- Choptie soils on knolls and hills
- Borobey soils in small basins and along drainageways

Major Use

Livestock grazing

Major Management Limitations

Wetness, climate, surface texture

General Management Considerations

- If seeding is needed, select plants that tolerate seasonal wetness.
- Grazing during wet periods can cause soil compaction and displacement and damage plants.
- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.

Range Site

Pumice Flat 9-11pz

148A—Swaler silt loam, 0 to 2 percent slopes

Composition

Swaler soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lake terraces
Parent material: Lacustrine sediment
Elevation: 4,100 to 4,600 feet
Native plants: Mountain big sagebrush, Idaho fescue, Thurber needlegrass, Indian ricegrass, basin wildrye
Climatic factors:
Mean annual precipitation—10 to 12 inches

Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 10 inches—light gray and light brownish gray silt loam
10 to 26 inches—brown and pale brown clay and silty clay loam
26 to 60 inches—pale brown and brown silty clay loam

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Moderately well drained
Ponding: 12 inches above the surface to a depth of 12 inches below the surface in March through May
Permeability: Very slow
Available water capacity: About 8 inches

Contrasting Inclusions

- Reluctan and Ninemile soils on lava plains
- Borobey soils in small basins and along drainageways
- Swalesilver soils in closed basins

Major Use

Livestock grazing

Major Management Limitations

Wetness, climate

General Management Considerations

- If seeding is needed, select plants that tolerate seasonal wetness.
- Grazing during wet periods can cause soil compaction and displacement and damage plants.
- The cold climate and soil temperature delay the growth of forage and shorten the growing season.

Range Site

Dry Lakebed 10-12pz

149A—Swalesilver loam, 0 to 1 percent slopes

Composition

Swalesilver soil and similar inclusions—90 percent
Contrasting inclusions—10 percent

Setting

Landscape position: Closed basins
Landform: Lava plains
Parent material: Lacustrine sediment
Elevation: 4,300 to 4,600 feet
Native plants: Silver sagebrush, mat muhly, Nevada bluegrass, creeping wildrye
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Typical Profile

0 to 3 inches—light gray loam
3 to 5 inches—light gray silt loam
5 to 18 inches—light brownish gray clay
18 to 40 inches—grayish brown silty clay loam
40 to 50 inches—pale brown clay loam
50 to 60 inches—light olive brown loam

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Somewhat poorly drained
Ponding: 12 inches above the surface to a depth of 12 inches below the surface in November through May
Permeability: Very slow
Available water capacity: About 11 inches

Contrasting Inclusions

- Reluctan soils on lava plains
- Swaler soils on drier edges of basins

Major Use

Livestock grazing

Major Management Limitations

Wetness, climate

General Management Considerations

- If seeding is needed, select plants that tolerate seasonal wetness.
- Grazing during wet periods can cause soil compaction and displacement and damage plants.
- The cold climate and soil temperature delay the growth of forage and shorten the growing season.

Range Site

Ponded Clay

150A—Tetherow sandy loam, 0 to 3 percent slopes

Composition

Tetherow soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash over cinders
Elevation: 2,500 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—70 to 100 days

Typical Profile

0 to 19 inches—brown sandy loam
19 to 24 inches—pale brown cobbly sandy loam
24 to 60 inches—dark reddish brown cinders

Soil Properties and Qualities

Depth: Cinders at a depth of 14 to 28 inches; bedrock at a depth of 60 inches or more
Drainage class: Excessively drained
Permeability: Moderately rapid over very rapid
Available water capacity: About 3 inches

Contrasting Inclusions

- Soils that are deep to cinders

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Surface texture, permeability

General Management Considerations

Irrigated cropland

- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.
- Applied fertilizers and chemicals may be leached and ground water may be contaminated because of the very rapid permeability of the substratum.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.

Range Site

Pumice Flat 10-12pz

150B—Tetherow sandy loam, 3 to 8 percent slopes

Composition

Tetherow soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lava plains
Parent material: Ash over cinders
Elevation: 2,500 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—70 to 100 days

Typical Profile

0 to 19 inches—brown sandy loam
19 to 24 inches—pale brown cobbly sandy loam
24 to 60 inches—dark reddish brown cinders

Soil Properties and Qualities

Depth: Cinders at a depth of 14 to 28 inches; bedrock at a depth of 60 inches or more
Drainage class: Excessively drained
Permeability: Moderately rapid over very rapid
Available water capacity: About 3 inches

Contrasting Inclusions

- Soils that are deep to cinders

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Surface texture, permeability, slope

General Management Considerations

Irrigated cropland

- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.
- Applied fertilizers and chemicals may be leached and ground water may be contaminated because of the

very rapid permeability of the substratum.
- Because of the steepness of slope, sprinkler irrigation systems should be used to minimize runoff.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.

Range Site

Pumice Flat 10-12pz

151D—Tetherow-Clovkamp complex, 8 to 50 percent slopes

Composition

Tetherow soil and similar inclusions—55 percent
Clovkamp soil and similar inclusions—30 percent
Contrasting inclusions—15 percent

Setting

Landform: Cinder cones
Slope range: Tetherow soil—8 to 50 percent; Clovkamp soil—8 to 25 percent
Parent material: Tetherow soil—ash over cinders (fig. 11); Clovkamp soil—ash
Elevation: 2,500 to 4,000 feet
Native plants: Tetherow soil—western juniper, Wyoming big sagebrush, bluebunch wheatgrass, Sandberg bluegrass; Clovkamp soil—western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—70 to 100 days

Figure 11.—Gravel pit used as a source of cinders in an area of Tetherow-Clovkamp complex, 8 to 50 percent slopes.

Typical Profile of the Tetherow Soil

0 to 7 inches—brown sandy loam
7 to 14 inches—brown sandy loam
14 to 60 inches—dark reddish brown cinders

Properties and Qualities of the Tetherow Soil

Depth: Cinders at a depth of 14 to 28 inches; bedrock at a depth of 60 inches or more
Drainage class: Excessively drained
Permeability: Moderately rapid over very rapid
Available water capacity: About 2 inches

Typical Profile of the Clovkamp Soil

0 to 12 inches—grayish brown and brown loamy sand
12 to 24 inches—brown loamy sand
24 to 40 inches—pale brown gravelly loamy fine sand
40 to 60 inches—pale brown extremely gravelly sand

Properties and Qualities of the Clovkamp Soil

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Moderate
Available water capacity: About 5 inches

Contrasting Inclusions

- Soils that have a weakly cemented layer at a depth of 10 to 40 inches
- Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Surface texture, permeability, slope

General Management Considerations

- Care should be taken to protect these soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the risk of seepage.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

- The steepness of slope restricts livestock distribution and limits range seeding with ground equipment.
- The steep, south-facing slopes are less suited to grazing in hot periods during the grazing season.

Range Site

Tetherow soil—Cindery Hills 10-12pz
Clovkamp soil—Pumice Flat 10-12pz

152A—Tumalo sandy loam, 0 to 3 percent slopes

Composition

Tumalo soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Outwash plains
Parent material: Ash over glacial outwash
Elevation: 3,000 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—70 to 100 days

Typical Profile

0 to 18 inches—grayish brown sandy loam
18 to 32 inches—pale brown very gravelly sandy loam
32 to 44 inches—very pale brown indurated duripan
44 to 90 inches—black and very pale brown extremely gravelly sand

Soil Properties and Qualities

Depth: Duripan at a depth of 20 to 40 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately rapid above the duripan and very rapid below the duripan
Available water capacity: About 4 inches

Contrasting Inclusions

- Soils that have a loamy sand or gravelly sandy loam surface layer
- Deschutes and Plainview soils in swales

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Soil depth, surface texture, permeability

General Management Considerations

Irrigated cropland

- Well-managed irrigation systems are needed for deep-rooted crops such as alfalfa.
- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and risk of seepage.

Range Site

Pumice Flat 10-12pz

152B—Tumalo sandy loam, 3 to 8 percent slopes

Composition

Tumalo soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Outwash plains
Parent material: Ash over glacial outwash
Elevation: 3,000 to 4,000 feet
Native plants: Western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, needleandthread
Climatic factors:
Mean annual precipitation—10 to 12 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—70 to 100 days

Typical Profile

0 to 18 inches—grayish brown sandy loam
18 to 32 inches—pale brown very gravelly sandy loam
32 to 44 inches—very pale brown indurated duripan
44 to 90 inches—black and very pale brown extremely gravelly sand

Soil Properties and Qualities

Depth: Duripan at a depth of 20 to 40 inches; bedrock at a depth of more than 60 inches

Drainage class: Well drained
Permeability: Moderately rapid above the duripan and very rapid below the duripan
Available water capacity: About 4 inches

Contrasting Inclusions

- Soils that have a loamy sand or gravelly sandy loam surface layer
- Deschutes and Plainview soils in swales

Major Uses

Irrigated cropland, livestock grazing

Major Management Limitations

Soil depth, surface texture, slope, permeability

General Management Considerations

Irrigated cropland

- Well-managed irrigation systems are needed for deep-rooted crops such as alfalfa.
- Because the surface layer is sandy loam, this soil is subject to wind erosion if left unprotected.
- Because of the steepness of slope, sprinkler irrigation systems should be used to minimize runoff.

Livestock grazing

- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and risk of seepage.

Range Site

Pumice Flat 10-12pz

153A—Tutni loamy coarse sand, 0 to 3 percent slopes

Composition

Tutni soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Pumice-mantled stream terraces
Parent material: Ash and pumice over old alluvium and colluvium
Elevation: 4,100 to 4,400 feet
Native plants: Lodgepole pine, bearberry
Climatic factors:
Mean annual precipitation—18 to 25 inches
Mean annual air temperature—40 to 44 degrees F
Frost-free period—10 to 50 days

Typical Profile

1 inch to 0—organic mat
0 to 10 inches—pale brown loamy coarse sand
10 to 43 inches—light yellowish brown very gravelly coarse sand
43 to 60 inches—brown sandy loam

Soil Properties and Qualities

Depth: Old alluvium at a depth of 40 to 60 inches; bedrock at a depth of 60 inches or more
Drainage class: Somewhat poorly drained
Depth to water table: 18 to 48 inches below the surface in April through June
Permeability: Rapid over moderately rapid
Available water capacity: About 4.5 inches

Contrasting Inclusions

- Soils that are very poorly drained or moderately well drained
- Lapine soils in higher positions

Major Use

Woodland

Major Management Limitations

Frost potential, wetness, rooting depth, low fertility, susceptibility to compaction

General Management Considerations

- Seedlings have a moderate survival rate because of the frost potential.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because roots are restricted by the seasonal high water table and the coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- The seasonal high water table restricts the use of equipment to midsummer when the soil is dry or to midwinter when the soil is frozen.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CL-M2-11

154A—Vergas loam, 0 to 3 percent slopes

Composition

Vergas soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Lake terraces
Parent material: Old alluvium
Elevation: 4,200 to 4,600 feet
Native plants: Basin big sagebrush, basin wildrye, bluebunch wheatgrass, Idaho fescue
Climatic factors:
  Mean annual precipitation—10 to 12 inches
  Mean annual air temperature—43 to 45 degrees F
  Frost-free period—50 to 90 days

Typical Profile

0 to 10 inches—light brownish gray and grayish brown loam
10 to 25 inches—pale brown clay loam
25 to 29 inches—pale brown gravelly loam
29 to 60 inches—pale brown, hard and brittle extremely gravelly loamy sand

Soil Properties and Qualities

Depth: Hard, brittle layer at a depth of 20 to 40 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Slow
Available water capacity: About 6 inches

Contrasting Inclusions

- Reluctan soils on higher toe slopes
- Swaler and Swalesilver soils in depressions

Major Use

Livestock grazing

Major Management Limitations

Climate, permeability

General Management Considerations

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Pond development is limited by the risk of seepage.

Range Site

Swale 10-14pz

155C—Wanoga sandy loam, 0 to 15 percent slopes

Composition

Wanoga soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Hills
Parent material: Ash
Elevation: 2,800 to 4,000 feet
Native plants: Ponderosa pine, western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, Ross sedge
Climatic factors:
  Mean annual precipitation—12 to 18 inches
  Mean annual air temperature—42 to 47 degrees F
  Frost-free period—60 to 90 days

Typical Profile

1 inch to 0—organic mat
0 to 12 inches—brown sandy loam
12 to 24 inches—brown sandy loam
24 to 34 inches—weathered tuff
34 inches—unweathered tuff

Soil Properties and Qualities

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 4 inches

Contrasting Inclusions

- Fremkle and Henkle soils on ridges
- Rock outcrop

Major Uses

Livestock grazing, woodland

Major Management Limitations

Climate, surface texture, soil depth, permeability, low fertility, susceptibility to compaction

General Management Considerations

Livestock grazing

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth, the

risk of seepage, and the steepness of slope in some areas.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Woodland

- Seedlings have a moderate survival rate because of the low precipitation.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Range Site

Pine-Juniper-Bitterbrush-Fescue

155D—Wanoga sandy loam, 15 to 30 percent slopes

Composition

Wanoga soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Hills
Parent material: Ash
Elevation: 2,800 to 4,000 feet
Native plants: Ponderosa pine, western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, Ross sedge
Climatic factors:
Mean annual precipitation—12 to 18 inches
Mean annual air temperature—42 to 47 degrees F
Frost-free period—60 to 90 days

Typical Profile

1 inch to 0—organic mat
0 to 12 inches—dark brown sandy loam
12 to 24 inches—brown sandy loam
24 to 34 inches—weathered tuff
34 inches—unweathered tuff

Soil Properties and Qualities

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 4 inches

Contrasting Inclusions

- Fremkle and Henkle soils on ridges
- Rock outcrop

Major Uses

Livestock grazing, woodland

Major Management Limitations

Climate, surface texture, soil depth, permeability, slope, low fertility, susceptibility to compaction

General Management Considerations

Livestock grazing

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth, risk of seepage, and steepness of slope.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Woodland

- Seedlings have a moderate survival rate because of the low precipitation.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Wheeled and tracked equipment can be used; however, cable yarding generally is safer and disturbs the soil less.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Range Site

Pine-Juniper-Bitterbrush-Fescue

155E—Wanoga sandy loam, 30 to 50 percent slopes

Composition

Wanoga soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Hills
Parent material: Ash
Elevation: 2,800 to 4,000 feet
Native plants: Ponderosa pine, western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, Ross sedge
Climatic factors:
Mean annual precipitation—12 to 18 inches
Mean annual air temperature—42 to 47 degrees F
Frost-free period—60 to 90 days

Typical Profile

1 inch to 0—organic mat
0 to 12 inches—dark brown sandy loam
12 to 24 inches—brown sandy loam
24 to 34 inches—weathered tuff
34 inches—unweathered tuff

Soil Properties and Qualities

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 4 inches

Contrasting Inclusions

- Fremkle and Henkle soils on ridges
- Rock outcrop

Major Uses

Livestock grazing, woodland

Major Management Limitations

Climate, surface texture, soil depth, permeability, slope, low fertility, susceptibility to compaction

General Management Considerations

Livestock grazing

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth, risk of seepage, and steepness of slope.
- The included areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.
- The steepness of slope restricts livestock distribution and limits range seeding with ground equipment.

Woodland

- Seedlings have a moderate survival rate because of the low precipitation.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Using machinery only in areas covered with logging

slash or brush reduces soil displacement.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Range Site

Pine-Juniper-Bitterbrush-Fescue

156C—Wanoga-Fremkle-Henkle complex, 0 to 15 percent slopes

Composition

Wanoga soil and similar inclusions—35 percent
Fremkle soil and similar inclusions—30 percent
Henkle and similar inclusions—20 percent
Contrasting inclusions—15 percent

Setting

Landform: Hills
Parent material: Ash
Elevation: 2,800 to 4,000 feet
Native plants: Wanoga soil—ponderosa pine, western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, Ross sedge; Fremkle and Henkle soils—western juniper, ponderosa pine, mountain big sagebrush, antelope bitterbrush, Idaho fescue, bluebunch wheatgrass
Climatic factors:
Mean annual precipitation—12 to 18 inches
Mean annual air temperature—42 to 47 degrees F
Frost-free period—60 to 90 days

Typical Profile of the Wanoga Soil

1 inch to 0—organic mat
0 to 12 inches—dark brown sandy loam
12 to 24 inches—brown sandy loam
24 to 34 inches—weathered tuff
34 inches—unweathered tuff

Properties and Qualities of the Wanoga Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 4 inches

Typical Profile of the Fremkle Soil

1 inch to 0—organic mat
0 to 14 inches—dark brown sandy loam
14 inches—tuff

Properties and Qualities of the Fremkle Soil

Depth: Bedrock at depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Typical Profile of the Henkle Soil

0.5 inch to 0—organic mat
0 to 17 inches—very dark brown and dark brown very cobbly sandy loam
17 inches—basalt

Properties and Qualities of the Henkle Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Somewhat excessively drained
Permeability: Moderately rapid
Available water capacity: About 1.5 inches

Contrasting Inclusions

- Laidlaw soils in swales
- Fryrear soils on side slopes and ridges

Major Uses

Livestock grazing, woodland

Major Management Limitations

Wanoga, Fremkle, and Henkle soils—climate, surface texture, permeability, soil depth, low fertility, susceptibility to compaction
Henkle soil—rock fragments in surface layer

General Management Considerations

Livestock grazing

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth, the risk of seepage, and the steepness of slope in some areas.
- The restricted depth of the Fremkle and Henkle soils limits the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface of the Henkle soil.

Woodland

- Seedlings have a moderate survival rate because of the low precipitation.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because roots are restricted by the shallow depth of the Fremkle and Henkle soils, trees are subject to windthrow.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Range Site

Wanoga soil—Pine-Juniper-Bitterbrush-Fescue
Fremkle and Henkle soils—Juniper-Pine-Fescue

156D—Wanoga-Fremkle-Henkle complex, 15 to 30 percent slopes

Composition

Wanoga soil and similar inclusions—35 percent
Fremkle soil and similar inclusions—30 percent
Henkle soil and similar inclusions—20 percent
Contrasting inclusions—15 percent

Setting

Landform: Hills
Parent material: Ash
Elevation: 2,800 to 4,000 feet
Native plants: Wanoga soil—ponderosa pine, western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, Ross sedge; Fremkle and Henkle soils—western juniper, ponderosa pine, mountain big sagebrush, antelope bitterbrush, Idaho fescue, bluebunch wheatgrass
Climatic factors:
Mean annual precipitation—12 to 18 inches
Mean annual air temperature—42 to 47 degrees F
Frost-free period—60 to 90 days

Typical Profile of the Wanoga Soil

1 inch to 0—organic mat
0 to 12 inches—dark brown sandy loam
12 to 24 inches—brown sandy loam
24 to 34 inches—weathered tuff
34 inches—unweathered tuff

Properties and Qualities of the Wanoga Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 4 inches

Typical Profile of the Fremkle Soil

1 inch to 0—organic mat
0 to 14 inches—dark brown sandy loam
14 inches—tuff

Properties and Qualities of the Fremkle Soil

Depth: Bedrock at depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Typical Profile of the Henkle Soil

0.5 inch to 0—organic mat
0 to 17 inches—very dark brown and dark brown very cobbly sandy loam
17 inches—basalt

Properties and Qualities of the Henkle Soil

Depth: Bedrock at a depth of 10 to 20 inches
Drainage class: Somewhat excessively drained
Permeability: Moderately rapid
Available water capacity: About 1.5 inches

Contrasting Inclusions

- Laidlaw soils in swales
- Fryrear soils on side slopes and ridges

Major Uses

Livestock grazing, woodland

Major Management Limitations

Wanoga, Fremkle, and Henkle soils—climate, surface texture, permeability, soil depth, slope, low fertility, susceptibility to compaction
Henkle soil—rock fragments in surface layer

General Management Considerations

Livestock grazing

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth, risk of seepage, and steepness of slope.

- The restricted depth of the Fremkle and Henkle soils limits the choice of species for range seeding to drought-tolerant varieties.
- Range seeding with ground equipment is limited by the rock fragments on the surface of the Henkle soil.

Woodland

- Seedlings have a moderate survival rate because of the low precipitation.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because roots are restricted by the shallow depth of the Fremkle and Henkle soils, trees are subject to windthrow.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Range Site

Wanoga soil—Pine-Juniper-Bitterbrush-Fescue
Fremkle and Henkle soils—Juniper-Pine-Fescue

157C—Wanoga-Fremkle-Rock outcrop complex, 0 to 15 percent slopes

Composition

Wanoga soil and similar inclusions—35 percent
Fremkle soil and similar inclusions—30 percent
Rock outcrop—20 percent
Contrasting inclusions—15 percent

Setting

Landform: Hills
Parent material: Ash
Elevation: 2,800 to 4,000 feet
Native plants: Wanoga soil—ponderosa pine, western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, Ross sedge; Fremkle soil—western juniper, ponderosa pine, mountain big sagebrush, antelope bitterbrush, Idaho fescue, bluebunch wheatgrass
Climatic factors:
Mean annual precipitation—12 to 18 inches
Mean annual air temperature—42 to 47 degrees F
Frost-free period—60 to 90 days

Typical Profile of the Wanoga Soil

1 inch to 0—organic mat
0 to 12 inches—dark brown sandy loam
12 to 24 inches—brown sandy loam
24 to 34 inches—weathered tuff
34 inches—unweathered tuff

Properties and Qualities of the Wanoga Soil

Depth: Bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 4 inches

Typical Profile of the Fremkle Soil

1 inch to 0—organic mat
0 to 14 inches—dark brown sandy loam
14 inches—tuff

Properties and Qualities of the Fremkle Soil

Depth: Bedrock at depth of 10 to 20 inches
Drainage class: Well drained
Permeability: Moderately rapid
Available water capacity: About 2 inches

Contrasting Inclusions

- Henkle soils on ridges
- Laidlaw soils in swales
- Fryrear soils on side slopes and ridges

Major Uses

Livestock grazing, woodland

Major Management Limitations

Rock outcrop, climate, surface texture, permeability, soil depth, low fertility, susceptibility to compaction

General Management Considerations

Livestock grazing

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soils from wind erosion when applying range improvement practices.
- Because the soils are influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth, the risk of seepage, and the steepness of slope in some areas.
- The restricted depth of the Fremkle soil limits the

choice of species for range seeding to drought-tolerant varieties.

- The areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Woodland

- Seedlings have a moderate survival rate because of the low precipitation.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because roots are restricted by the shallow depth of the Fremkle soil, trees are subject to windthrow.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- The areas of Rock outcrop force yarding and skidding paths to converge, which increases the risks of compaction and erosion throughout the unit.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Range Site

Wanoga soil—Pine-Juniper-Bitterbrush-Fescue
Fremkle soil—Juniper-Pine-Fescue

158A—Wickiup loamy sand, 0 to 3 percent slopes

Composition

Wickiup soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landscape position: Swales and depressions
Landform: Stream terraces
Parent material: Volcanic ash and pumice
Elevation: 4,300 to 5,000 feet
Native plants: Lodgepole pine, sedges, and grasses
Climatic factors:
  Mean annual precipitation—18 to 25 inches
  Mean annual air temperature—40 to 44 degrees F
  Frost-free period—10 to 50 days

Typical Profile

4 inches to 0—organic mat
0 to 4 inches—light brownish gray loamy sand
4 to 10 inches—very pale brown very gravelly coarse sand
10 to 60 inches—white extremely gravelly coarse sand

Soil Properties and Qualities

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Poorly drained
Depth to water table: At the surface to a depth of 30 inches below the surface from March through October
Permeability: Rapid
Available water capacity: About 3 inches

Contrasting Inclusions

- Soils that are moderately well drained or poorly drained
- Lapine soils in higher positions

Major Use

Woodland

Major Management Limitations

Wetness, frost potential, soil texture, low fertility, susceptibility to compaction

General Management Considerations

- Seedlings have a moderate survival rate because of the seasonal high water table and frost potential.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because roots are restricted by the seasonal high water table and the coarse-textured soil has insufficient anchoring capability, trees are subject to windthrow.
- The seasonal high water table restricts the use of equipment to midsummer when the soil is dry or to midwinter when the soil is frozen.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CL-M1-11

159C—Wilt sandy loam, 0 to 15 percent slopes

Composition

Wilt soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Hills
Parent material: Ash over residuum
Elevation: 2,800 to 4,000 feet
Native plants: Ponderosa pine, western juniper, mountain big sagebrush, antelope bitterbrush, Idaho fescue, Ross sedge
Climatic factors:
Mean annual precipitation—12 to 18 inches
Mean annual air temperature—42 to 47 degrees F
Frost-free period—60 to 90 days

Typical Profile

0 to 13 inches—dark brown sandy loam
13 to 26 inches—dark brown cobbly loam
26 to 33 inches—dark brown very cobbly clay loam
33 inches—andesite

Soil Properties and Qualities

Depth: Residuum at a depth of 7 to 14 inches; bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 4.5 inches

Contrasting Inclusions

- Soils that have a very cobbly clay loam or clay subsoil
- Fryrear soils on side slopes

Major Uses

Livestock grazing, woodland

Major Management Limitations

Climate, surface texture, soil depth, low fertility, susceptibility to compaction

General Management Considerations

Livestock grazing

- The cold climate and soil temperature delay the growth of forage and shorten the growing season.
- Care should be taken to protect the soil from wind erosion when applying range improvement practices.
- Because the soil is influenced by pumice ash, reestablishment of the native vegetation is very slow if the vegetation is removed or deteriorated.
- Pond development is limited by the soil depth and by the steepness of slope in some areas.

Woodland

- Seedlings have a moderate survival rate because of the low precipitation.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Range Site

Pine-Juniper-Bitterbrush-Fescue

160C—Windego-Parrego complex, 0 to 15 percent slopes

Composition

Windego soil and similar inclusions—45 percent
Parrego soil and similar inclusions—40 percent
Contrasting inclusions—15 percent

Setting

Landform: Mountains
Parent material: Ash over colluvium and residuum
Elevation: 2,500 to 3,500 feet
Native plants: Ponderosa pine, antelope bitterbrush, greenleaf manzanita, needlegrasses
Climatic factors:
Mean annual precipitation—15 to 25 inches
Mean annual air temperature—42 to 47 degrees F
Frost-free period—60 to 90 days

Typical Profile of the Windego Soil

1 inch to 0—organic mat
0 to 19 inches—dark brown and brown sandy loam
19 to 30 inches—brown very cobbly loam
30 to 60 inches—dark brown and yellowish brown very cobbly clay loam

Properties and Qualities of the Windego Soil

Depth: Colluvium at a depth of 14 to 25 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 6 inches

Typical Profile of the Parrego Soil

3 inches to 0—organic mat

0 to 5 inches—dark brown sandy loam
5 to 13 inches—brown loam
13 to 24 inches—brown clay loam
24 inches—weathered tuff

Properties and Qualities of the Parrego Soil

Depth: Colluvium at a depth of 4 to 7 inches; soft bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 4 inches

Contrasting Inclusions

- Smiling soils on side slopes

Major Use

Woodland

Major Management Limitations

Climate, low fertility, susceptibility to compaction

General Management Considerations

- Seedlings have a moderate survival rate because of the low precipitation.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CP-S2-13

160D—Windego-Parrego complex, 15 to 30 percent slopes

Composition

Windego soil and similar inclusions—45 percent
Parrego soil and similar inclusions—40 percent
Contrasting inclusions—15 percent

Setting

Landform: Mountains
Parent material: Ash over colluvium and residuum
Elevation: 2,500 to 3,500 feet
Native plants: Ponderosa pine, antelope bitterbrush, greenleaf manzanita, needlegrasses
Climatic factors:
Mean annual precipitation—15 to 25 inches
Mean annual air temperature—42 to 47 degrees F
Frost-free period—60 to 90 days

Typical Profile of the Windego Soil

1 inch to 0—organic mat
0 to 19 inches—dark brown and brown sandy loam
19 to 30 inches—brown very cobbly loam
30 to 60 inches—dark brown and yellowish brown very cobbly clay loam

Properties and Qualities of the Windego Soil

Depth: Colluvium at a depth of 14 to 25 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 6 inches

Typical Profile of the Parrego Soil

3 inches to 0—organic mat
0 to 5 inches—dark brown sandy loam
5 to 13 inches—brown loam
13 to 24 inches—brown clay loam
24 inches—weathered tuff

Properties and Qualities of the Parrego Soil

Depth: Colluvium at a depth of 4 to 7 inches; soft bedrock at a depth of 20 to 40 inches
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 4 inches

Contrasting Inclusions

- Smiling soils on side slopes

Major Use

Woodland

Major Management Limitations

Climate, slope, low fertility, susceptibility to compaction

General Management Considerations

- Seedlings have a moderate survival rate because of the low precipitation.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Wheeled and tracked equipment can be used; however, cable yarding generally is safer and disturbs the soil less.

- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CP-S2-13

161E—Windego-Smiling complex, 30 to 50 percent slopes

Composition

Windego soil and similar inclusions—55 percent
Smiling soil and similar inclusions—30 percent
Contrasting inclusions—15 percent

Setting

Landform: Mountains
Parent material: Ash over colluvium
Elevation: 2,500 to 3,500 feet
Native plants: Windego soil—ponderosa pine, antelope bitterbrush, greenleaf manzanita, needlegrasses; Smiling soil—ponderosa pine, antelope bitterbrush, greenleaf manzanita, Idaho fescue
Climatic factors:
Mean annual precipitation—20 to 40 inches
Mean annual air temperature—42 to 47 degrees F
Frost-free period—60 to 90 days

Typical Profile of the Windego Soil

1 inch to 0—organic mat
0 to 19 inches—dark brown and brown sandy loam
19 to 30 inches—brown very cobbly loam
30 to 60 inches—dark brown and yellowish brown very cobbly clay loam

Properties and Qualities of the Windego Soil

Depth: Colluvium at a depth of 14 to 25 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 6 inches

Typical Profile of the Smiling Soil

1 inch to 0—organic mat
0 to 16 inches—very dark brown and dark brown sandy loam
16 to 39 inches—dark brown loam
39 to 63 inches—dark brown clay loam

Properties and Qualities of the Smiling Soil

Depth: Colluvium at a depth of 14 to 33 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 10 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 20 to 40 inches
- Rock outcrop on ridges

Major Use

Woodland

Major Management Limitations

Slope, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Using machinery only in areas covered with logging slash or brush reduces soil displacement.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

Windego soil—CP-S2-13
Smiling soil—CP-S2-17

162E—Windego-Smiling complex, cool, 30 to 50 percent slopes

Composition

Windego soil and similar inclusions—50 percent
Smiling soil and similar inclusions—35 percent
Contrasting inclusions—15 percent

Setting

Landform: Mountains
Parent material: Ash over colluvium
Elevation: 3,500 to 4,000 feet
Native plants: Ponderosa pine, Douglas fir, snowbrush, chinkapin, brackenfern
Climatic factors:
Mean annual precipitation—30 to 50 inches
Mean annual air temperature—40 to 45 degrees F
Frost-free period—50 to 70 days

Typical Profile of the Windego Soil

1 inch to 0—organic mat
0 to 19 inches—dark brown and brown sandy loam
19 to 30 inches—brown very cobbly loam
30 to 60 inches—dark brown and yellowish brown very cobbly clay loam

Properties and Qualities of the Windego Soil

Depth: Colluvium at a depth of 14 to 25 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 6 inches

Typical Profile of the Smiling Soil

1 inch to 0—organic mat
0 to 16 inches—very dark brown and dark brown sandy loam
16 to 39 inches—dark brown loam
39 to 63 inches—dark brown clay loam

Properties and Qualities of the Smiling Soil

Depth: Colluvium at a depth of 14 to 33 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 10 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 20 to 40 inches
- Rock outcrop on ridges

Major Use

Woodland

Major Management Limitations

Slope, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Using machinery only in areas covered with logging slash or brush reduces soil displacement.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CW-C2-11

163D—Windego-Smiling-Rock outcrop complex, 0 to 30 percent slopes

Composition

Windego soil and similar inclusions—50 percent
Smiling soil and similar inclusions—25 percent
Rock outcrop—20 percent
Contrasting inclusions—5 percent

Setting

Landform: Mountains
Parent material: Ash over colluvium
Elevation: 2,500 to 3,500 feet
Native plants: Windego soil—ponderosa pine, antelope bitterbrush, greenleaf manzanita, needlegrasses; Smiling soil—ponderosa pine,

antelope bitterbrush, greenleaf manzanita, Idaho fescue

Climatic factors:
Mean annual precipitation—20 to 40 inches
Mean annual air temperature—42 to 47 degrees F
Frost-free period—60 to 90 days

Typical Profile of the Windego Soil

1 inch to 0—organic mat
0 to 19 inches—dark brown and brown sandy loam
19 to 30 inches—brown very cobbly loam
30 to 60 inches—dark brown and yellowish brown very cobbly clay loam

Properties and Qualities of the Windego Soil

Depth: Colluvium at a depth of 14 to 25 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 6 inches

Typical Profile of the Smiling Soil

1 inch to 0—organic mat
0 to 16 inches—very dark brown and dark brown sandy loam
16 to 39 inches—dark brown loam
39 to 63 inches—dark brown clay loam

Properties and Qualities of the Smiling Soil

Depth: Colluvium at a depth of 14 to 33 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 10 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 20 to 40 inches
- Parrego soils on side slopes of Green Ridge

Major Use

Woodland

Major Management Limitations

Rock outcrop, slope, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Wheeled and tracked equipment can be used; however, cable yarding generally is safer and disturbs the soil less.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

Windego soil—CP-S2-13
Smiling soil—CP-S2-17

163E—Windego-Smiling-Rock outcrop complex, 30 to 70 percent slopes

Composition

Windego soil and similar inclusions—50 percent
Smiling soil and similar inclusions—25 percent
Rock outcrop—20 percent
Contrasting inclusions—5 percent

Setting

Landform: Mountains
Parent material: Ash over colluvium
Elevation: 2,500 to 3,500 feet
Native plants: Windego soil—ponderosa pine, antelope bitterbrush, greenleaf manzanita, needlegrasses; Smiling soil—ponderosa pine, antelope bitterbrush, greenleaf manzanita, Idaho fescue
Climatic factors:
Mean annual precipitation—20 to 40 inches
Mean annual air temperature—42 to 47 degrees F
Frost-free period—60 to 90 days

Typical Profile of the Windego Soil

1 inch to 0—organic mat
0 to 19 inches—dark brown and brown sandy loam
19 to 30 inches—brown very cobbly loam

30 to 60 inches—dark brown and yellowish brown very cobbly clay loam

Properties and Qualities of the Windego Soil

Depth: Colluvium at a depth of 14 to 25 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 6 inches

Typical Profile of the Smiling Soil

1 inch to 0—organic mat
0 to 16 inches—very dark brown and dark brown sandy loam
16 to 39 inches—dark brown loam
39 to 63 inches—dark brown clay loam

Properties and Qualities of the Smiling Soil

Depth: Colluvium at a depth of 14 to 33 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderately slow
Available water capacity: About 10 inches

Contrasting Inclusions

- Soils that have bedrock at a depth of 20 to 40 inches
- Parrego soils on side slopes of Green Ridge

Major Use

Woodland

Major Management Limitations

Rock outcrop, slope, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Using machinery only in areas covered with logging slash or brush reduces soil displacement.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

Windego soil—CP-S2-13
Smiling soil—CP-S2-17

164A—Wizard sandy loam, 0 to 3 percent slopes

Composition

Wizard soil and similar inclusions—85 percent
Contrasting inclusions—15 percent

Setting

Landform: Outwash plains
Parent material: Ash over glacial outwash
Elevation: 2,500 to 3,500 feet
Native plants: Ponderosa pine, white fir, common snowberry, twinflower
Climatic factors:
Mean annual precipitation—20 to 35 inches
Mean annual air temperature—40 to 47 degrees F
Frost-free period—50 to 90 days

Typical Profile

2 inches to 0—organic mat
0 to 23 inches—dark brown sandy loam
23 to 28 inches—dark yellowish brown cobbly sandy loam
28 to 65 inches—dark yellowish brown very cobbly sandy loam

Soil Properties and Qualities

Depth: Glacial outwash at a depth of 20 to 40 inches; bedrock at a depth of 60 inches or more
Drainage class: Somewhat poorly drained
Depth to water table: At the surface to a depth of 24 inches below the surface in April through June
Permeability: Moderately rapid
Available water capacity: About 6 inches

Contrasting Inclusions

- Allingham and Circle soils in higher positions
- Flarm soils in swales

Major Use

Woodland

Major Management Limitations

Wetness, low fertility, susceptibility to compaction

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because roots are restricted by the seasonal high water table, trees are subject to windthrow.
- The seasonal high water table restricts the use of equipment to midsummer when the soil is dry or to midwinter when the soil is frozen.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

CD-S6-12

165C—Wizard-Allingham complex, 0 to 15 percent slopes

Composition

Wizard soil and similar inclusions—45 percent
Allingham soil and similar inclusions—45 percent
Contrasting inclusions—10 percent

Setting

Landform: Outwash plains
Parent material: Ash over glacial outwash
Elevation: 2,500 to 3,500 feet
Native plants: Wizard soil—ponderosa pine, white fir, common snowberry, twinflower; Allingham soil—ponderosa pine, antelope bitterbrush, greenleaf manzanita, Idaho fescue
Climatic factors:
Mean annual precipitation—20 to 35 inches
Mean annual air temperature—40 to 47 degrees F
Frost-free period—50 to 90 days

Typical Profile of the Wizard Soil

2 inches to 0—organic mat
0 to 23 inches—dark brown sandy loam
23 to 28 inches—dark yellowish brown cobbly sandy loam
28 to 65—dark yellowish brown very cobbly sandy loam

Properties and Qualities of the Wizard Soil

Depth: Glacial outwash at a depth of 20 to 40 inches; bedrock at a depth of 60 inches or more
Drainage class: Somewhat poorly drained
Depth to water table: At the surface to a depth of 24 inches below the surface in April through June
Permeability: Moderately rapid
Available water capacity: About 6 inches

Typical Profile of the Allingham Soil

1 inch to 0—organic mat
0 to 16 inches—very dark grayish brown and dark brown gravelly sandy loam
16 to 28 inches—dark brown loam
28 to 65 inches—dark yellowish brown very gravelly and very cobbly clay loam

Properties and Qualities of the Allingham Soil

Depth: Glacial outwash at a depth of 20 to 40 inches; bedrock at a depth of 60 inches or more
Drainage class: Well drained
Permeability: Moderate
Available water capacity: About 8 inches

Contrasting Inclusions

- Circle soils in higher positions
- Flarm soils in swales and channels

Major Use

Woodland

Major Management Limitations

Wizard and Allingham soils—low fertility, susceptibility to compaction
Wizard soil—wetness

General Management Considerations

- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Because roots are restricted by the seasonal high water table, trees on the Wizard soil are subject to windthrow.
- The seasonal high water table in the Wizard soil restricts the use of equipment to midsummer when the soil is dry or to midwinter when the soil is frozen.
- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.

- Because of the moderate susceptibility to compaction, designated skid trails should be used.

Forest Service Plant Association

Wizard soil—CD-S6-12
Allingham soil—CP-S2-17

166D—Xerolls, 5 to 50 percent slopes

Composition

Xerolls and similar inclusions—95 percent
Contrasting inclusions—5 percent

Setting

Landform: Slumps and landslides
Parent material: Colluvium and ash
Elevation: 1,400 to 2,000 feet
Native plants: Western juniper, Wyoming big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—9 to 11 inches
Mean annual air temperature—47 to 52 degrees F
Frost-free period—110 to 140 days

Representative Profile

0 to 6 inches—grayish brown loam
6 to 18 inches—grayish brown loam
18 to 60 inches—light brownish gray sandy loam

Soil Properties and Qualities

Depth: Bedrock at a depth of 10 to 60 inches or more
Drainage class: Moderately well drained to somewhat excessively drained
Permeability: Moderately rapid to slow
Available water capacity: 2 to 6 inches

Contrasting Inclusions

- Rock outcrop

Major Use

Livestock grazing

Major Management Limitations

Soil depth, permeability, climate, slope, aspect

General Management Considerations

- Pond development is limited by the soil depth, risk of seepage, and steepness of slope.
- The low annual precipitation and restricted soil depth limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- The steepness of slope restricts livestock distribution and limits range seeding with ground equipment.
- The steep, south-facing slopes are less suited to grazing in hot periods during the grazing season.

Range site

Onsite investigation is needed to determine the range site.

167E—Xerolls-Rock outcrop complex, 30 to 65 percent north slopes

Composition

Xerolls and similar inclusions—60 percent
Rock outcrop—25 percent
Contrasting inclusions—15 percent

Setting

Landform: Hills
Parent material: Basalt, welded tuff, ash
Elevation: 4,000 to 5,500 feet
Native plants: Western juniper, mountain big sagebrush, Idaho fescue, bluebunch wheatgrass
Climatic factors:
Mean annual precipitation—9 to 11 inches
Mean annual air temperature—43 to 45 degrees F
Frost-free period—50 to 90 days

Representative Profile of Xerolls

0 to 6 inches—grayish brown very stony loam
6 to 18 inches—grayish brown loam
18 to 60 inches—light brownish gray sandy loam

Properties and Qualities of Xerolls

Depth: Bedrock at a depth of 10 to 60 inches or more
Drainage class: Moderately well drained to somewhat excessively drained
Permeability: Moderately rapid to slow
Available water capacity: 2 to 6 inches

Contrasting Inclusions

- Reluctan and Ninemile soils on lava plains
- Swaler and Borobey soils on toe slopes
- Choptie soils in ravines and on escarpments

Major Use

Livestock grazing

Major Management Limitations

Rock outcrop, soil depth, permeability, climate, slope

General Management Considerations

- Pond development is limited by the soil depth and risk of seepage.

- The low annual precipitation and restricted soil depth limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- The steepness of slope restricts livestock distribution and limits range seeding with ground equipment.
- The areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

Pumice North 9-12pz

168E—Xerolls-Rock outcrop complex, 30 to 65 percent south slopes

Composition

Xerolls and similar inclusions—45 percent
Rock outcrop—40 percent
Contrasting inclusions—15 percent

Setting

Landform: Hills
Parent material: Basalt, welded tuff, ash
Elevation: 3,000 to 5,500 feet
Native plants: Western juniper, Wyoming big sagebrush, antelope bitterbrush, bluebunch wheatgrass, Sandberg bluegrass
Climatic factors:
Mean annual precipitation—9 to 11 inches
Mean annual air temperature—46 to 48 degrees F
Frost-free period—50 to 90 days

Representative Profile of Xerolls

0 to 6 inches—grayish brown very stony loam
6 to 18 inches—grayish brown loam
18 to 60 inches—light brownish gray sandy loam

Properties and Qualities of Xerolls

Depth: Bedrock at a depth of 10 to 60 inches or more
Drainage class: Moderately well drained to somewhat excessively drained
Permeability: Moderately rapid to slow
Available water capacity: 2 to 6 inches

Contrasting Inclusions

- Reluctan and Ninemile soils on lava plains
- Swaler and Borobey soils on toe slopes
- Choptie soils in ravines and on escarpments

Major Use

Livestock grazing

Major Management Limitations

Rock outcrop, soil depth, permeability, climate, slope, aspect

General Management Considerations

- Pond development is limited by the soil depth, risk of seepage, and steepness of slope.
- The low annual precipitation and restricted soil depth limit productivity and limit the choice of species for range seeding to drought-tolerant varieties.
- The steepness of slope restricts livestock distribution and limits range seeding with ground equipment.
- The steep, south-facing slopes are less suited to grazing in hot periods during the grazing season.
- The areas of Rock outcrop limit the areas suitable for grazing and restrict accessibility by livestock.

Range Site

South 9-12pz

169C—Yapoah-Rock outcrop complex, 0 to 15 percent slopes

Composition

Yapoah soil and similar inclusions—70 percent
Rock outcrop—20 percent
Contrasting inclusions—10 percent

Setting

Landform: Mountains
Parent material: Ash and colluvium
Elevation: 3,200 to 5,000 feet
Native plants: Ponderosa pine, antelope bitterbrush, greenleaf manzanita, Idaho fescue
Climatic factors:
Mean annual precipitation—18 to 30 inches
Mean annual air temperature—40 to 47 degrees F
Frost-free period—50 to 90 days

Typical Profile of the Yapoah Soil

2 inches to 0—organic mat
0 to 12 inches—dark brown very cobbly loamy sand
12 to 60 inches—dark yellowish brown extremely flaggy loamy sand

Properties and Qualities of the Yapoah Soil

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Rapid
Available water capacity: About 2 inches

Contrasting Inclusions

- Sisters soils on side slopes
- Soils that have bedrock at a depth of 20 to 60 inches

Major Use

Woodland

Major Management Limitations

Rock outcrop, available water capacity, rock fragments

General Management Considerations

- Seedlings have a poor survival rate because of the low available water capacity.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Rock fragments in the soil restrict the planting of seedlings.

Forest Service Plant Association

CP-S2-17

169E—Yapoah-Rock outcrop complex, 15 to 75 percent slopes

Composition

Yapoah soil and similar inclusions—65 percent
Rock outcrop—20 percent
Contrasting inclusions—15 percent

Setting

Landform: Mountains
Parent material: Ash and colluvium
Elevation: 3,200 to 5,000 feet
Native plants: Ponderosa pine, antelope bitterbrush, greenleaf manzanita, Idaho fescue
Climatic factors:
Mean annual precipitation—18 to 30 inches
Mean annual air temperature—40 to 47 degrees F
Frost-free period—50 to 90 days

Typical Profile of the Yapoah Soil

2 inches to 0—organic mat
0 to 12 inches—dark brown very cobbly loamy sand
12 to 60 inches—dark yellowish brown extremely flaggy loamy sand

Properties and Qualities of the Yapoah Soil

Depth: Bedrock at a depth of 60 inches or more
Drainage class: Somewhat excessively drained
Permeability: Rapid
Available water capacity: About 2 inches

Contrasting Inclusions

- Sisters soils on side slopes
- Soils that have bedrock at a depth of 20 to 60 inches

Major Use

Woodland

Major Management Limitations

Rock outcrop, available water capacity, slope, rock fragments

General Management Considerations

- Seedlings have a poor survival rate because of the low available water capacity.
- Unless the site is properly prepared and maintained, undesirable plants may compete with reforestation.
- Competing vegetation can be reduced by mechanical treatment, chemical treatment, or livestock grazing.
- High-lead logging or other logging systems that fully or partially suspend logs generally are safer and less damaging to the soil surface.
- Increased erosion, loss of nutrients, and water repellency may result from fires that have moderate fireline intensity.
- Burning should be carefully planned to minimize detrimental impacts to the soil.
- Cuts and fills can be protected from erosion by seeding with grass and mulching.
- Reduce erosion and sedimentation by using water bars and relief culverts; insloping, outsloping, or crowning road surfaces; using sediment traps; and undulating road grades.
- Reduce the risk of erosion on tractor skid roads and

temporary roads by seeding, installing water bars, subsoiling, or accumulating slash on the surface.

- Because of the low fertility of the subsoil, displacement of the surface layer should be minimized.
- Using machinery only in areas covered with logging slash or brush reduces soil displacement.
- Rock fragments in the soil restrict the planting of seedlings.

Forest Service Plant Association

CP-S2-17

Use and Management of the Soils

This soil survey is an inventory and evaluation of the soils in the survey area. It can be used to adjust land uses to the limitations and potentials of natural resources and the environment. Also, it can help to prevent soil-related failures in land uses.

In preparing a soil survey, soil scientists, conservationists, engineers, and others collect extensive field data about the nature and behavioral characteristics of the soils. They collect data on erosion, droughtiness, flooding, and other factors that affect various soil uses and management. Field experience and collected data on soil properties and performance are used as a basis in predicting soil behavior.

Information in this section can be used to plan the use and management of soils for crops and pasture; as rangeland and woodland; as sites for buildings, sanitary facilities, highways and other transportation systems, and parks and other recreational facilities; and for wildlife habitat. It can be used to identify the potentials and limitations of each soil for specific land uses and to help prevent construction failures caused by unfavorable soil properties.

Planners and others using soil survey information can evaluate the effect of specific land uses on productivity and on the environment in all or part of the survey area. The survey can help planners to maintain or create a land use pattern in harmony with the natural soil.

Contractors can use this survey to locate sources of sand and gravel, roadfill, and topsoil. They can use it to identify areas where bedrock, wetness, or very firm soil layers can cause difficulty in excavation.

Health officials, highway officials, engineers, and others may also find this survey useful. The survey can help them plan the safe disposal of wastes and locate sites for pavements, sidewalks, campgrounds, playgrounds, lawns, and trees and shrubs.

Crops and Pasture

By Rich Edlund and Ray Wilson, district conservationists, Natural Resources Conservation Service.

Cropland comprises about 10 percent of the survey area. General management needed for crops and pasture is suggested in this section. The estimated yields of the important crops or hay and pasture plants are given, the system of land capability classification used by the Natural Resources Conservation Service is explained, and prime farmland is described.

This section provides information about the agricultural potential of the survey area and suggests the management needed to help maintain this potential. This information is useful to agricultural producers, equipment and fertilizer dealers, land use planners, contractors, and conservationists. Information about the management of each soil is given in the section “Detailed Soil Map Units.” This information is useful in planning management systems for individual farms and fields.

According to the 1987 Census of Agriculture, approximately 90,000 acres in Jefferson County was used as cropland. Of this, about 45,000 acres was used for irrigated crops. Most of the irrigated cropland is in the vicinity of Madras, Metolius, and Culver. In Deschutes County, there are about 60,000 acres of irrigated cropland, pastureland, and hayland. Most of this land is in the vicinity of Redmond, Bend, Alfalfa, and Terrebonne. In Klamath County, it is not economically feasible to grow crops because of the cool temperatures in summer and the short growing season.

Nonirrigated cropland is scattered throughout the survey area. A grain-fallow rotation system is used on most of this land. Alfalfa is incorporated into the rotation in some areas.

Soils have various properties that affect use and management. Susceptibility to erosion by water and wind is an important consideration. Erosion results in a loss of organic matter and a breakdown of soil structure, and it changes soil texture through a loss of sand, silt, and clay. Onsite effects of erosion include degradation of soil tilth and loss of productivity, and offsite effects include degradation of water and air quality. It takes many years to replace soil lost through erosion.

The survey area has a wide range of soils and climatic conditions that influence use and management for crops and pasture. The northern part of the survey area, in Jefferson County, has the most favorable conditions for crop production. Elevation is 2,300 to

2,600 feet. The frost-free period is about 100 days, and the annual rainfall is less than 12 inches. Crops grown under irrigation include wheat, barley, grass seed, mint, alfalfa hay, potatoes, and seed crops such as garlic, flowers, radishes, and carrots.

Soils of the Madras and Agency series make up the majority of the acreage under cultivation. These soils are moderately fine textured and are moderately deep to bedrock. They are limited by the permeability of the subsoil and the sandy loam texture of the surface layer. Irrigation water should be applied according to the infiltration rate and permeability of the soils. Overirrigating contributes to erosion and runoff. Soil particles transported by water carry nutrients and chemicals into waterways and reservoirs, reducing storage capacity and making costly cleanup operations necessary. The quality of the water is degraded, making it less suitable for irrigation, livestock, and domestic use. Wind erosion is a concern in the areas of Madras and Agency soils that have a sandy loam surface layer. In addition to the loss of productivity, wind erosion creates a safety hazard on highways and results in deposition of soil material in waterways and reservoirs.

The Calimus soils are similar to the Madras and Agency soils, but they are less than 20 inches deep to bedrock. The very low available water capacity and the slow permeability of the subsoil in the Calimus soils make careful scheduling of irrigation necessary to avoid overland flow and crop stress.

Soils of the Era series are very deep and moderately coarse textured, and they have few limitations for crop production. These soils are in areas of nearly level to rolling topography. Sprinkler irrigation systems should be used in areas that have slopes of more than 3 percent to minimize erosion. Use of minimum tillage, crop residue, and windbreaks is needed to reduce wind erosion.

In the southern part of Jefferson County and the western part of Deschutes County, the soils and climatic conditions change dramatically. Elevation is 3,000 feet at Redmond and 3,500 feet at Bend. The frost-free period is about 80 days, which limits the choice of crops. Agriculture consists mainly of irrigated pasture and hay and smaller acreages of potatoes for seed, mint for rootstock and oil, and spring grain. The soils include those of the Clovkamp, Deschutes, Houstake, Tumalo, and Deskamp series. These soils consist of sandy loam and loamy sand influenced by pumice ash deposited from Mt. Mazama. The texture affects the infiltration rate, permeability, and available water capacity. Because of the high infiltration rate and the moderately rapid or rapid permeability, applying irrigation water at a higher rate than is typical for the needs of the crop grown is common. Sprinkler irrigation is best suited because the rate and frequency of application can be regulated according to individual crop needs. The very low or low available water capacity, which is a result of the soil depth and texture, makes more frequent applications necessary.

The infiltration rate is determined by the texture, structure, and organic matter content of a soil. For example, sandy soils have a high infiltration rate but they have a low available water capacity. Conversely, clayey soils absorb water slowly but they have a relatively high available water capacity. Various crops require differing amounts of water for full production. Applying adequate water during critical growth stages helps to maintain high production and desirable crop quality.

Many structural, management, and vegetative practices are used to reduce or control erosion by wind and water. Soils that have a bare surface are highly susceptible to wind and water erosion. Plant cover reduces the impact of raindrops and decreases the erosive energy of wind. It also increases the rate of infiltration of water into the soil profile. Windbreaks reduce the velocity of the wind, thus reducing the risk of erosion. Maintaining crop residue on the soil surface reduces erosion, increases the infiltration rate, and incorporates organic matter into the soil, which increases the available water capacity and the content of nutrients.

Yields per Acre

The average yields per acre that can be expected of the principal crops under a high level of management are shown in table 5. In any given year, yields may be higher or lower than those indicated in the table because of variations in rainfall and other climatic factors. The land capability classification of each map unit also is shown in the table.

The yields are based mainly on the experience and records of farmers, conservationists, and extension agents. Available yield data from nearby counties and results of field trials and demonstrations are also considered.

The management needed to obtain the indicated yields of the various crops depends on the kind of soil and the crop. Management can include drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate and timely tillage; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residue, barnyard manure, and green manure crops; and harvesting that ensures the smallest possible loss.

For yields of irrigated crops, it is assumed that the irrigation system is adapted to the soils and to the crops grown, that good-quality irrigation water is uniformly applied as needed, and that tillage is kept to a minimum.

The estimated yields reflect the productive capacity of each soil for each of the principal crops. Yields are likely to increase as new production technology is developed. The productivity of a given soil compared with that of other soils, however, is not likely to change.

Crops other than those shown in the table are grown in the survey area, but estimated yields are not listed because the acreage of such crops may be small. The local office of the Natural Resources Conservation Service or of the Cooperative Extension Service can provide information about the management and productivity of the soils for those crops.

Land Capability Classification

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The criteria used in grouping the soils do not include major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor do they include possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, for woodland, and for engineering purposes.

In the capability system *(24)*, soils are generally grouped at three levels—capability class, subclass, and unit. Only class and subclass are used in this survey.

Capability classes, the broadest groups, are designated by numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants or that require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants or that require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use.

Class VI soils have severe limitations that make them generally unsuitable for cultivation.

Class VII soils have very severe limitations that make them unsuitable for cultivation.

Class VIII soils and miscellaneous areas have limitations that nearly preclude their use for commercial crop production.

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e, w, s,* or *c,* to the class numeral, for example, IIe. The letter *e* shows that the main hazard is the risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c,* used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry.

In class I there are no subclasses because the soils of this class have few limitations. Class V contains only the subclasses indicated by *w, s,* or *c* because the soils in class V are subject to little or no erosion. They have other limitations that restrict their use to pasture, rangeland, woodland, wildlife habitat, or recreation.

The capability classification of each map unit in this survey area is given in table 5.

Prime Farmland

Prime farmland is one of several kinds of important farmland defined by the U.S. Department of Agriculture. It is of major importance in meeting the Nation’s short- and long-range needs for food and fiber. Because the supply of high-quality farmland is limited, the U.S. Department of Agriculture recognizes that responsible levels of government, as well as individuals, should encourage and facilitate the wise use of our Nation’s prime farmland.

Prime farmland, as defined by the U.S. Department of Agriculture, is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is available for these uses. It could be cultivated land, pastureland, forest land, or other land, but it is not urban or built-up land or water areas. The soil qualities, growing season, and moisture supply are those needed for the soil to economically produce sustained high yields of crops when proper management, including water management, and acceptable farming methods are applied. In general, prime farmland has an adequate and dependable supply of moisture from precipitation or irrigation, a favorable temperature and growing season, acceptable acidity or alkalinity, an acceptable salt and sodium content, and few or no rocks. It is permeable to water and air. It is not excessively erodible or saturated with water for long periods, and it either is not frequently flooded during the growing season or is protected from flooding. The slope ranges mainly from 0 to 8 percent. More detailed information about the criteria for prime farmland is available at the local office of the Natural Resources Conservation Service.

About 168,000 acres, or about 10 percent of the survey area, would meet the requirements for prime farmland if an adequate and dependable supply of irrigation water were available.

A recent trend in land use in some parts of the survey area has been the loss of some prime farmland to industrial and urban uses. The loss of prime farmland to other uses puts pressure on marginal lands, which generally are more erodible, droughty, and less productive and cannot be easily cultivated.

The map units in the survey area that are considered prime farmland or potential prime farmland are listed in this section. This list does not constitute a recommendation for a particular land use. On some soils included in the list, measures that overcome a hazard or limitation, such as flooding, wetness, and droughtiness, are needed. Onsite evaluation is needed to determine whether or not the hazard or limitation has been overcome by corrective measures. The extent of each listed map unit is shown in table 4. The location is shown on the detailed soil maps at the back of this publication. The soil qualities that affect use and management are described under the heading “Detailed Soil Map Units.”

The map units that meet the requirements for prime farmland if irrigated are:

1A	Agency sandy loam, 0 to 3 percent slopes
2A	Agency loam, 0 to 3 percent slopes
2B	Agency loam, 3 to 8 percent slopes
3B	Agency-Madras complex, 0 to 8 percent slopes
23A	Buckbert sandy loam, 0 to 3 percent slopes
26A	Clinefalls sandy loam, 0 to 3 percent slopes
27A	Clovkamp loamy sand, 0 to 3 percent slopes
28A	Clovkamp loamy sand, bedrock substratum, 0 to 3 percent slopes
31A	Deschutes sandy loam, 0 to 3 percent slopes
31B	Deschutes sandy loam, 3 to 8 percent slopes
32A	Deschutes sandy loam, dry, 0 to 3 percent slopes
33B	Deschutes-Houstake complex, 0 to 8 percent slopes
36A	Deskamp loamy sand, 0 to 3 percent slopes
36B	Deskamp loamy sand, 3 to 8 percent slopes
37B	Deskamp sandy loam, 3 to 8 percent slopes
44B	Era sandy loam, 3 to 8 percent slopes
45A	Era sandy loam, cobbly substratum, 0 to 3 percent slopes
65A	Houstake sandy loam, 0 to 3 percent slopes
66A	Houstake sandy loam, dry, 0 to 3 percent slopes
67A	Houstake sandy loam, very gravelly substratum, 0 to 3 percent slopes
68A	Iris silt loam, 0 to 1 percent slopes
71B	Lafollette sandy loam, 3 to 8 percent slopes
86A	Madras sandy loam, 0 to 3 percent slopes
86B	Madras sandy loam, 3 to 8 percent slopes
87A	Madras loam, 0 to 3 percent slopes
87B	Madras loam, 3 to 8 percent slopes
98A	Plainview sandy loam, 0 to 3 percent slopes
98B	Plainview sandy loam, 3 to 8 percent slopes
104A	Redmond sandy loam, 0 to 3 percent slopes
150A	Tetherow sandy loam, 0 to 3 percent slopes
150B	Tetherow sandy loam, 3 to 8 percent slopes
152A	Tumalo sandy loam, 0 to 3 percent slopes
152B	Tumalo sandy loam, 3 to 8 percent slopes

Rangeland

By Gene Hickman, range conservationist, Natural Resources Conservation Service.

Rangeland comprises about 60 percent of the survey area. It includes juniper savanna, shrub grassland, and meadows or riparian habitat. The rangeland is adjacent to the forest land along the foot slopes of the Cascade Mountains and extends eastward into central and eastern Oregon. The vegetation produced on rangeland helps to control erosion, conserve water, and maintain watersheds; provides habitat for wildlife; and offers scenic and recreational opportunities. Rangeland also provides important year-round forage for wildlife and livestock. For these reasons, it is important economically and environmentally.

Importance and Uses of Rangeland

Over the past century, livestock grazing has been one of the most significant uses of the rangeland. Although the number of livestock on the rangeland has declined in recent years, cattle grazing is still vital to the local economy. Sheep ranchers once grazed large flocks in the survey area when moving to summer range in the Cascades. Most sheep operations have changed from large range flocks to smaller farm flocks. Horses and llamas have become a significant component of many livestock operations.

In addition to the historic and economic importance of the rangeland for livestock grazing, it is also important for many other uses. It helps to control flooding and prevent excessive soil erosion in watersheds and riparian areas. Rangeland watersheds capture, store, and release water for plant growth and for recharge of springs and streams.

Rangeland provides habitat for many game and nongame mammals and birds and for fish and other wildlife. Consequently, sport hunting and fishing are major industries in the survey area. Other recreation opportunities include wildlife viewing, photography, landscape painting, off-road vehicle use, and sightseeing.

Historically, local Native Americans obtained edible plants from the rangeland.

Broad Vegetative Zones

Livestock and wildlife in the survey area graze and browse in a wide variety of environments that support varied vegetative cover types. These broad zones, which are characterized by the dominant soils and potential native vegetation, are discussed in this section.

Natural vegetation in the survey area varies greatly because of the wide range in climate and the contrasting topographic features. In addition, an extensive mantle of ash and pumice covers much of the area. The soils have low inherent fertility, higher than expected available water capacity, and thermal properties that are less conducive to heat transfer.

From the high, moist, cold soils of the Cascade Mountains eastward to the dry, cool soils of the lava plains, known as the High Desert, climate is associated with the major differences in the types of vegetation over short distances. Precipitation decreases from 70 inches in the forests of the Cascade Mountains to about 8 inches in the Madras and Redmond areas. Soils that are influenced by ash and pumice extend nearly to the eastern boundary of the survey area.

From north to south in the survey area, there is a gradual decrease in temperature, increase in moisture, and increase in elevation. The warmer, lower elevations at the northern end of the area have the longest growing season. The soils have little ash and pumice influence except in some local deposits. The area south of Juniper Butte to Bend and west to Hampton has been influenced significantly by volcanic ash from Mt. Mazama. Soil temperatures in this zone become cooler as the content of ash and the elevation increase.

In the area south of Bend, the thickness of the ash and pumice mantle increases significantly. Temperatures are cold, and freezing temperatures may occur at any time during the year. The vegetation near Bend consists of ponderosa pine plant communities, and in the LaPine Basin it consists of lodgepole pine plant communities.

Mixed Conifer Zone. This zone is characterized by general soil map units 15 and 20. The forests commonly include various combinations of white fir, Douglas fir, ponderosa pine, incense cedar, and some lodgepole pine. The dense stands generally are not grazed by livestock unless the overstory canopy is opened by fire or logging. Forage is sparse in areas where there is an abundance of unpalatable evergreen shrubs such as chinkapin, snowbrush, manzanita, and Oregongrape. This zone traditionally has been used as summer range for both livestock and big game. It is characterized by cold temperatures in winter and cool temperatures in summer, and it receives the highest amount of precipitation of any part of the survey area. Deep snow commonly is on the ground throughout winter, and it remains until late in spring or early in summer. New plant growth occurs very late.

Ponderosa Pine Zone. This zone is characterized by general soil map units 14, 16, 18, and 19. Ponderosa pine forests are at the lower elevations and in areas that receive less precipitation than the adjacent mixed conifer zone. The ponderosa pine zone has two very distinct subdivisions based on understory vegetation. Manzanita and snowbrush are prominent in the understory of the cooler, more moist area adjacent to the mixed conifer zone. Antelope bitterbrush is dominant in the understory in the warmer, drier area adjacent to the sagebrush juniper zone. Forage is readily available throughout the ponderosa pine zone because of the abundance of palatable species such as Idaho fescue, bottlebrush squirreltail, needlegrass, Ross sedge, and antelope bitterbrush. This zone has a natural open overstory canopy, which allows light to reach the understory. As a result, palatable species are abundant and the zone is suited to grazing even with minimal forest management or harvesting.

Lodgepole Pine Zone. This zone is dominant in the LaPine Basin. It is characterized by general soil map units 2 and 3 and the associated meadows in general soil map unit 1. This very cold lava plain has very deep and deep deposits of pumice and ash and has interspersed buttes and low ridges. Lodgepole pine forests are dominant on the toe slopes and lower lying flat areas that are affected by cold air drainage. Wet basins and poorly drained areas along the Upper Deschutes River system are associated with a variety of riparian communities. Higher lying areas on buttes and uplands support ponderosa pine forests and some mixed conifer forests.

Forage production is very high in the meadows in this zone. The pine forests, however, are less suited to grazing by livestock because of the scarcity of water and the very low production of herbaceous vegetation. These forests support a variety of understory shrubs, including dominantly antelope bitterbrush along with wax currant and in some places manzanita, bearberry, and squawcarpet. Herbaceous cover consists primarily of western needlegrass, bottlebrush squirreltail, Ross sedge, and Idaho fescue.

Sagebrush Juniper Zone. The sagebrush juniper zone is characterized by general soil map units 4, 5, 6, 7, 8, 9, 10, and 17. Western juniper is a key species in the management of rangeland and woodland. The amount and density of western juniper has increased over the last 150 to 300 years. This increase has been attributed to the control of fire and possibly other factors such as overgrazing and changes in climate *(21)*. Because range sites and associated plant species and composition are based on a climax plant community in which fire is considered to be a part of the ecosystem, western juniper is present on many soils in which it is not considered to be part of the historic climax plant community. Managers should compare the historic climax vegetative potential of a range or woodland site to the present-day vegetation. Suitable management alternatives depend on the objectives and goals of the land managers.

Within the sagebrush juniper zone, there are three important subdivisions based on soil properties. The southern part of the zone is strongly influenced by ash. It is characterized by general soil map units 5, 6, 8, and 17. The primary shrub species are mountain big sagebrush, rabbitbrush, desert gooseberry, and buckwheat. In areas that receive more than about 10 inches of precipitation, antelope bitterbrush commonly is the dominant shrub. The dominant grasses in the southern part include Idaho fescue, needleandthread, bottlebrush squirreltail, Indian ricegrass, Ross sedge, and bluebunch wheatgrass. Idaho fescue is less abundant and needleandthread is more abundant in the areas that receive less precipitation. Grazing is limited by the lack of natural surface water for livestock and by the extensive network of lava outcroppings. Reestablishment of western juniper is very slow after trees are removed by fire or mechanical means.

The northern part of the zone has minimal ash influence except for some local accumulation in the lower lying positions. This part is characterized by general soil map units 4, 7, and 9. The primary shrub species are basin big sagebrush, antelope bitterbrush, gray horsebrush, rabbitbrush, and buckwheat. The main grasses are bluebunch wheatgrass, Idaho fescue, Thurber needlegrass, Sandberg bluegrass, and bottlebrush squirreltail. Winters are mild in this part, and spring growth begins earlier because the growing season is longer.

A small area in this zone is represented by more clayey soils that are not influenced by ash. This area is characterized by general soil map unit 10. The primary shrubs and grasses are similar to those in the northern part of the this zone. Western juniper is more invasive on these soils, and it regenerates quickly after disturbance or if protected from fire. Because the soils are clayey and the topography is steep, the risk of water erosion is higher in this area than in other parts of the survey area.

Sagebrush Zone. This zone is in the eastern part of the survey area, extending eastward from the crest of Horse Ridge. It is characterized by general soil map units 11, 12, and 13. Temperatures are colder and the growing season is shorter than in the sagebrush juniper zone to the west. The sagebrush zone traditionally has been used for livestock grazing late in spring and in fall.

General soil map unit 11 is in a basin that is subject to cold air drainage. This unit does not support western juniper. The vegetation is dominantly mountain big sagebrush, Idaho fescue, and needlegrasses. In the southwestern part of the unit, near Pine Mountain, antelope bitterbrush is also a major species. This unit receives only about 10 to 12 inches of precipitation, which typically is considered inadequate for Idaho fescue. However, the coarse-textured soils are high in content of ash and have a higher than expected available water capacity, which compensates for the lower precipitation and allows Idaho fescue to become dominant. Areas of this unit are interspersed with numerous small, clayey basins that are ponded during spring runoff and support silver sagebrush and with dry drainageways that support basin wildrye and basin big sagebrush.

General soil map unit 12 is on a lava plain. The soils are shallow and have a thin mantle of ash. Western juniper is dominant in the plant community. Low sagebrush and mountain big sagebrush are the dominant shrubs, and Idaho fescue is the dominant grass. Areas of this unit are interspersed with seasonally ponded, clayey basins that support silver sagebrush and sparse herbaceous cover. The extreme eastern part of unit 12, near Hampton, has very little ash influence and is subject to less cold air drainage than is unit 11. Because of the lower available water capacity and the slightly warmer temperatures, Wyoming big sagebrush and bluebunch wheatgrass are dominant in this part of the unit.

General soil map unit 13 is on hills. Western juniper is throughout much of this unit. Mountain big sagebrush is the dominant shrub, and Idaho fescue and needlegrasses are the dominant grasses.

Grazing Management

Livestock management includes many practices. The key to proper management is use of a grazing system designed with consideration of plant and animal requirements, topography, and management objectives. A grazing system includes pasture rotation, proper use of forage, proper timing and length of the grazing period, and rest or deferred grazing until after critical periods of plant growth. Other practices, such as fencing, salting, using water developments, controlling weeds and brush, thinning, and seeding, are used to facilitate the grazing system and to improve livestock distribution or to increase production.

An important objective of grazing management should be maintenance or improvement of the soil, water, and plant resources. Because of the economic impact and other considerations, the objective of management may not be to improve the range condition or site potential. However, proper management is needed to achieve an acceptable level of cover and production consistent with the limitations of the vegetative site. This level should conserve water, maintain water quality, and minimize erosion.

Limitations for Use

Soil characteristics can make an area unsuitable or less suitable for particular grazing practices. Important limitations are given in the section “Detailed Soil Map Units.” Some soil characteristics that could affect grazing management are described in this section.

Aspect is the direction in which a slope faces. North-facing slopes are cooler and more productive, but development of new growth occurs later in the year on these slopes. North-facing slopes are preferred by livestock and wildlife in summer. South-facing slopes generally have the opposite characteristics of north-facing slopes. Because south-facing slopes are warmer and drier, they are poorly suited to livestock grazing in summer. They are very important to wildlife in winter, however, because less snow accumulates on these slopes and they are the first to green up in spring. Southeast- and west-facing slopes have characteristics similar to those of south-facing slopes.

Droughtiness limits the production of forage and the choice of species suitable for seeding. Soils are droughty as a result of low annual precipitation or low available water capacity. Soil characteristics such as coarse texture, shallow depth, or a high content of rock fragments limit the available water capacity.

Cold temperatures restrict the length of the growing season. Below-normal daily temperatures during the growing season also suppress plant growth and delay plant development.

A *high water table* occurs seasonally in some soils and year-round in others. Wetness, even if the root zone is saturated only briefly, has a major effect on the composition and production of the plant community. This is particularly true if a soil is ponded or has a water table at or near the surface. Soils that have a water table near the surface are subject to compaction and displacement and the plants are subject to crown damage if grazing is allowed during wet periods. If these soils are seeded, mechanical site preparation is difficult because of the abundant vegetation and the limited period when equipment can be used. The species selected for seeding should be tolerant of seasonal wetness.

Rock outcrop and escarpments support little, if any, vegetation. In areas where they make up a significant portion of the map unit, the capacity of the unit for grazing is reduced proportionally. Outcroppings and escarpments act as physical barriers to all domestic livestock and to some wildlife, preventing or restricting movement.

Livestock water developments are needed in most of the grazeable areas in the survey area. Development of stock ponds is limited in many areas because of the lack of water sources, such as springs or runoff; insufficient soil depth; and a shortage of proper construction material. Unless material for sealing the ponds is brought in from outside the area, ponds can be constructed only in areas where the soil material naturally has slow permeability and can be compacted and sealed properly. Soils that are coarse textured, are high in content of rock fragments, or are shallow or moderately deep to bedrock are subject to excessive seepage and are poorly suited to pond construction. The high infiltration rate and rapid permeability of most of the soils in the area limit runoff. Water for ponds may need to be transported to an area or pumped from wells.

Steepness of slope affects livestock use and the feasibility of applying management practices. Areas that have slopes of 30 percent or less are preferred by livestock. Areas that have slopes of more than 50 percent receive very little use even if the forage is abundant. Limited use of the steeper slopes should be anticipated, and the stocking rates should be adjusted accordingly. Areas that have slopes of more than about

35 percent generally are not suited to mechanical seedbed preparation or to seeding with ground equipment.

Stones and cobbles on the surface can influence grazing management and the potential for revegetation. Some soils have so many stones and cobbles on the surface that livestock avoid the soils whenever possible. Stones can limit the feasibility of mechanical seedbed preparation and seeding.

Surface texture can affect the suitability for livestock grazing and for applying management practices. Some soils that have a silty surface layer are subject to crusting and are sticky when wet. The crusting of the surface reduces infiltration and restricts seedling emergence. Soils that have a clayey surface layer have a slow or very slow infiltration rate and are very sticky and very plastic when wet. The surface becomes rutted and compacted if the soil is grazed or traversed by equipment when wet. Most of the soils in the survey area have a coarse-textured, or sandy, surface layer. These soils are susceptible to wind erosion if the vegetation is removed or is sparse. Management of these soils should include maintaining adequate litter and plant cover. The coarse-textured soils that receive less than about 12 inches of precipitation are very susceptible to deterioration of the vegetative site. Loss of native perennial cover through fire, mechanical treatment, or overgrazing can result in a rapid conversion of a potential native plant community to invasive weedy brush and annual vegetation. Reestablishment of native bunchgrass plant communities is very slow.

In areas that have similar climate and topography, differences in the kind and amount of vegetation produced on rangeland are closely related to the kind of soil. Effective management is based on the relationship between the soils and vegetation and water.

Table 6 shows, for each soil that supports rangeland vegetation suitable for grazing, the range site; the total annual production of vegetation in favorable, normal, and unfavorable years; the characteristic vegetation; and the average percentage of each species. An explanation of the column headings in the table follows.

A *range site* is a distinctive kind of rangeland that produces a characteristic natural plant community that differs from natural plant communities on other range sites in kind, amount, and proportion of range plants. The relationship between soils and vegetation was ascertained during this survey; thus, range sites generally can be determined directly from the soil map. Soil properties that affect moisture supply and plant nutrients have the greatest influence on the productivity of range plants. Soil reaction, salt content, and a seasonal high water table are also important.

Total production is the amount of vegetation that can be expected to grow annually on well managed rangeland that is supporting the potential natural plant community. It includes all vegetation, whether or not it is palatable to grazing animals. It includes the current year's growth of leaves, twigs, and fruits of woody plants. It does not include the increase in stem diameter of trees and shrubs. It is expressed in pounds per acre of air-dry vegetation for favorable, normal, and unfavorable years. In a favorable year, the amount and distribution of precipitation and the temperatures make growing conditions substantially better than average. In a normal year, growing conditions are about average. In an unfavorable year, growing conditions are well below average, generally because of low available soil moisture.

Dry weight is the total annual yield per acre of air-dry vegetation. Yields are adjusted to a common percent of air-dry moisture content. The relationship of green weight to air-dry weight varies according to such factors as exposure, amount of shade, recent rains, and unseasonable dry periods.

Characteristic vegetation—the grasses, forbs, and shrubs that make up most of the potential natural plant community on each soil—is listed by common name. Under *composition*, the expected percentage of the total annual production is given for each species making up the characteristic vegetation. The amount that can be used as forage depends on the kinds of grazing animals and on the grazing season.

Range management requires a knowledge of the kinds of soil and of the potential natural plant community. It also requires an evaluation of the present range condition. Range condition is determined by comparing the present plant community with the potential natural plant community on a particular range site. The more closely the existing community resembles the potential community, the better the range condition. Range condition is an ecological rating only.

The objective in range management is to control grazing so that the plants growing on a site are about the same in kind and amount as the potential natural plant community for that site. Such management generally results in the optimum production of vegetation, control of undesirable brush species, conservation of water, and control of erosion. Sometimes, however, a range condition somewhat below the potential meets grazing needs, provides wildlife habitat, and protects soil and water resources.

Woodland Management and Productivity

By Craig M. Ziegler and Russ Hatz, foresters, Natural Resources Conservation Service.

Forest land comprises about 30 percent of the survey area. It is concentrated in the southern and western parts of the area. A majority of the forest land is public land that is administered by the Forest Service. The remainder is owned by commercial timber companies and private landowners. Precipitation ranges from about 15 to 70 inches.

The forests in the southern part of the survey area are mainly in the LaPine Basin. Elevation in the basin ranges from about 4,000 to 5,000 feet or more. The soils are influenced by volcanic ash and pumice. At the southern end of the basin the deposits of volcanic ash and pumice are as much as 60 inches thick or more, and at the northern end they are about 24 inches thick. The soils are cold and are low in fertility. They have a high available water capacity, but they dry out very quickly early in the growing season. There are two main forest cover types in this part of the survey area—interior ponderosa pine and lodgepole pine *(19)*. The interior ponderosa pine type is on lava plains and hills. Many years of fire control have allowed lodgepole pine to become established in the understory. Areas of Lapine, Shanahan, and Steiger soils support this forest cover type. The lodgepole pine type is in low-lying or depressional areas on pumice-mantled lava plains. Cold air drainage is trapped in these areas, and the resulting frost is detrimental to ponderosa pine. Areas of Lapine, Shanahan, Steiger, Sunriver, Tutni, and Wickiup soils support this forest cover type.

The forests in the western part of the survey area are more diverse. The dominant forest cover type is interior ponderosa pine. It is at the lower elevations and in drier areas. Ponderosa pine is the dominant tree species, but Douglas fir, western larch, white fir, and western juniper occur in lesser amounts. The interior Douglas fir and white fir cover types generally are at the middle elevations, and the lodgepole pine cover type is at the higher elevations. The soils in the western part also have been influenced by volcanic activity. The layers of pumice and ash are a few inches thick to more than 60 inches thick. The farther away the soils are from the Cascade Range, the thinner the layers of pumice and ash. The proximity of the soils to various volcanic events and the direction and velocity of the wind also influence the thickness of the pumice and ash. The soils in this part have moderate fertility and high available water capacity.

Several large wood products manufacturers are in or near the survey area. Ponderosa pine, the most prevalent tree species, and Douglas fir and white fir are used for lumber, plywood, and wood chips. Lodgepole pine is used for wood chips, plywood, and fence posts. Dead lodgepole pine is used extensively for firewood.

Many diseases and insects affect the forests and can be a problem in individual stands of trees. Damage varies from year to year. The mountain pine beetle *(Dendroctonus ponderosae)* is very destructive to forests. Large numbers of lodgepole pine, the principal host, periodically are killed, and individual trees are killed annually. The pine engraver beetle also attacks pine species. The western spruce budworm *(Choristoneura occidentalis)* defoliates Douglas fir and white fir, dramatically reducing growth. The western pine beetle *(Dendroctonus brevicomis)* attacks larger pine trees, and the western pine shoot borer *(Eucosma sonomia)* attacks younger pine trees.

Dwarf mistletoe *(Arceuthobium spp.)* is one of the most destructive parasites that attacks ponderosa pine, Douglas fir, and western larch. Red ring rot *(Fomes pini)* is a disease that kills western larch and lodgepole pine. Shoestring root rot *(Armillaria mellea)* is a problem for pines under stress and for Douglas fir and true firs. Brown stringy rot *(Echinodontium tinctorium)* is a serious disease of Douglas fir and true firs.

Soil surveys are important to land managers as they seek ways to maximize the use of forest land. This survey provides to managers information that can be used to make sound management decisions. Table 7 can be used by woodland owners and forest managers in planning the use of the soils for wood crops. Only the soils suitable for wood crops are listed. *Slight*, *moderate*, and *severe* indicate the degree of the major soil limitations to be considered in management.

Sheet and rill erosion ratings refer to the probability of excessive erosion occurring as a result of operations that expose the soil. Forests that are burned or overgrazed are also subject to sheet and rill erosion. A *slight* rating indicates that no particular erosion-control measures are needed under ordinary conditions; *moderate* indicates that some erosion-control measures are needed; and *severe* indicates that extra precautions are needed to control erosion during most silvicultural activities.

Erosion hazard ratings are determined by considering the topography, the erodibility of a soil, and the local climate. Moderate and severe ratings may indicate the need to modify road construction, use special harvesting systems, and use alternative site preparation techniques.

Cut and fill erosion ratings refer to the probability that damage will occur as a result of erosion from road cuts and fills. All cuts and fills should be seeded. A *slight* rating indicates that no other preventative measures are needed under ordinary conditions; *moderate* indicates that additional erosion-control measures, such as use of mulch and sediment traps, are needed under certain conditions; and *severe* indicates that additional erosion-control measures are needed under most conditions.

The texture of the surface layer and subsoil and the length and angle of the slope contribute to the extent of the cut and fill erosion. The risk of erosion is greater in areas where the cuts and fills are longer and the erodibility of the soil is higher.

Equipment limitation ratings refer to the limits on the use of equipment as a result of soil characteristics. A rating of *slight* indicates that equipment use normally is not restricted because of soil factors; *moderate* indicates a short seasonal limitation because of soil wetness, a fluctuating water table, or some other factor; and *severe* indicates a seasonal limitation, a need for special equipment, or a hazard in the use of equipment.

Steepness of slope, soil wetness, and the susceptibility of the soil to compaction are the main limitations for equipment use. As the gradient and length of the slope increase, use of wheeled equipment becomes more difficult. Tracked equipment can be used in some of the steeper areas, but cable yarding systems should be used in the steepest areas. Soil wetness, especially in areas of fine-textured material, can severely limit the use of equipment and make harvesting practical only during the dry period in summer.

Soil compaction ratings refer to the probability that damage will occur to the soil structure as a result of repeated use of equipment when the soil is wet or moist. Compaction should always be considered during silvicultural activities. A rating of *slight* indicates that the only special practices needed are use of designated skid trails and protection of the layer of duff; *moderate* indicates the potential need for extra precautions, such as use of cable yarding instead of ground skidding and seasonal restrictions on equipment use; and *severe* indicates the need for extreme caution and possibly some restorative activities, such as ripping or discing, following harvesting.

Thickness of the layer of duff, content of coarse fragments, texture, and plasticity are characteristics of the soil that are considered in the compaction ratings. Compaction decreases air spaces in the soil; thus, air and water movement are reduced, which restricts root growth and increases the risk of surface erosion.

Soil displacement ratings refer to the soil being gouged, scraped, or pushed from its natural position by mechanical means. Soil displacement is most often associated with mechanical slash disposal and site preparation. A *slight* rating indicates that equipment use is not restricted and that special precautions generally are not needed; *moderate* indicates that specialized equipment, such as a brush rake, should be used; and *severe* indicates that extreme caution is needed if mechanical slash disposal and site preparation are used.

Soil characteristics considered in the soil displacement ratings are thickness of the layer of duff, thickness of the surface layer, content of coarse fragments, and texture. Removing or mixing the layer of duff and exposing the mineral soil are necessary for natural regeneration of many species. If excessive soil displacement has occurred, however, plant recovery rates may be impaired. Because of the inherent low fertility of material influenced by pumice and ash, most of the nutrients and organic matter are in the upper few inches of the mineral soil. Prolonged exposure may increase the risk of erosion and further deteriorate the site.

Seedling mortality ratings refer to the probability of death of tree seedlings because of soil characteristics or topographic conditions. Plant competition is not considered in this rating. The ratings apply to healthy, dormant seedlings from good stock that are properly planted during a period of sufficient moisture. A rating of *slight* indicates that no problem is expected under normal conditions; *moderate* indicates that some problems can be expected and extra precautions are needed; and *severe* indicates that mortality will be high and extra precautions are needed for successful reforestation.

Soil wetness, droughtiness, and topographic conditions contribute to seedling mortality. To overcome these limitations, larger than normal planting stock, special site preparation, surface drainage, or reinforcement plantings may be needed.

Windthrow ratings refer to the soil characteristics that affect the development of tree roots and the ability of the soil to hold trees firmly. A rating of *slight* indicates that trees normally are not blown down by the wind; *moderate* indicates that an occasional tree may be blown down during periods when the soil is wet and winds are moderate or strong; and *severe* indicates that many trees may be blown down during periods when the soil is wet and the winds are moderate or strong.

Restricted rooting depth because of a high water table, underlying bedrock, or an impervious layer and poor anchoring of roots because of loose soil material are the main factors contributing to the windthrow hazard. Moderate and severe ratings indicate the need for care in thinning forest stands, periodic salvage of windblown trees, and adequate roads and trails to allow for salvage operations.

Plant competition ratings refer to the likelihood of the invasion of undesirable plants when openings are made in the tree canopy. A *slight* rating indicates that unwanted plants are not likely to retard the development of natural or planted seedlings; *moderate* indicates that competition will retard the development of natural or planted seedlings; and *severe* indicates that competition can be expected to prevent the development of natural or planted seedlings.

Favorable climate and soil characteristics result in plant competition problems. In many cases, the key to predicting plant competition is the quantity and proximity of seed sources of undesirable plants or the quantity of unwanted brush rootstock that will resprout after harvesting. Moderate and severe ratings indicate the need for careful and thorough site preparation and the potential need for mechanical or chemical treatment to retard the growth of competing vegetation.

Fire damage ratings refer to the probability that a fire of moderate fireline intensity (116 to 520 Btu's/sec/ft) will have a negative impact on the characteristics of the soil. A rating of *slight* indicates that negative impacts are not expected; *moderate* indicates that negative impacts, such as nonwettability and excessive erosion, may occur and extra caution is needed in planning prescribed fires; and *severe* indicates that negative impacts are likely to occur and extreme caution is needed in planning prescribed fires.

Thickness of the layer of duff, content of organic matter, and texture are soil characteristics considered in determining the ability of soil to resist fire damage. It may be necessary to burn in winter, use alternative lighting techniques, monitor the moisture content of the fuel, yard unmerchantable material, eliminate prescribed fires, or use erosion-control measures following burning.

In table 8, the potential productivity of forested soils is expressed as *site index*. The site index is the average height dominant and codominant trees will attain at a base age. For example, a site index of 70 (50-year base age) means that the dominant and codominant trees will reach an average height of 70 feet in 50 years and a site index of 120 (100-year base age) means that the dominant and codominant trees will reach an average height of 120 feet in 100 years.

While it seems logical that a soil with a site index of 90 is more productive than a soil with a site index of 70, such a conclusion can be made only if the same tree species are compared and if the site indexes were derived from the same equations or tables. The tables used to compute site index vary according to species, and more than one site index table can be used for an individual species. Any given soil may have more than one site index, depending on the number of species the soil supports. Several publications were used to determine site index for this survey area *(1, 2, 9, 10, 12, 14, 17)*.

To facilitate comparing the potential productivity of different soils, the table includes values for potential wood production expressed as *total yield (board feet per acre)* and *annual growth (cubic feet per acre)*. Estimates of volume are calculated at the culmination of the mean annual increment (CMAI). The annual amount of wood fiber produced by a stand of trees changes as the stand matures. Very little wood fiber is produced when the trees are small, but the amount increases rapidly as the trees approach physiological maturity. Once trees reach maturity, the annual growth rate begins to slow. CMAI is the estimated age at which a fully stocked stand achieves its highest average annual growth rate. It is the most efficient time to harvest as far as tree growth is concerned. Other factors, such as stumpage values, cost effectiveness, and management objectives, also should be considered in determining the best time to harvest.

As an example of how the table can be used, consider the Allingham soil in detailed soil map unit 4C. A fully stocked stand of ponderosa pine on this soil has a site index of 77; that is, the average height of the dominant and codominant trees at age 100 is 77 feet. If the stand is allowed to grow for 160 years, the predicted yield will be 33,400 board feet per acre. However, the stand will attain its maximum annual production of wood fiber (64 cubic feet per acre per year) at age 50.

The species under *common trees* that are indicated by a footnote notation are ones that are recommended for planting and are most suitable for commercial wood production.

Woodland Understory Vegetation

The detailed soil map units in this survey area have been correlated to a range site or plant association. The site or association, such as South 9-12pz or CD-S6-13, respectively, is given at the end of each map unit description. For those map units or components assigned to a range site, the vegetative information on production, characteristic vegetation, and composition is given in table 6. For those map units or components assigned to a plant association, the vegetative information on characteristic vegetation and composition is provided in the publication "Plant Associations of the Central Oregon Pumice Zone" *(20)*.

Windbreaks and Environmental Plantings

By Craig Ziegler, forester, Natural Resources Conservation Service.

Wind erosion can be a serious environmental and economic problem. It can reduce the productivity of a soil through the loss of topsoil. Properly designed windbreaks can increase crop yields. Many environmental changes occur on the leeward side of windbreaks, including reduced windspeed, decreased transpiration by plants, increased humidity, reduced evaporation, and increased soil moisture content.

Field windbreaks are narrow plantings made at right angles to the prevailing wind and at specific intervals. The proper interval depends on the erodibility of the soil. Research has shown that field windbreaks can significantly increase crop yields. Cropland damage by wind erosion was at an all-time high during the latter half of the 1980's as a result of removal or deterioration of older, existing windbreaks. Field windbreaks offer farmers an effective conservation practice to reduce wind erosion.

For windbreaks to be effective, the species of trees or shrubs selected must be adapted to the soils. Permeability, available water capacity, fertility, and depth of the soil affect the growth of trees and shrubs.

Droughtiness in summer and cold temperatures in winter can lower the survival rate of trees and shrubs in the survey area. Properly preparing the site before planting and controlling competing vegetation after planting are essential for establishing new windbreaks. Replanting during the first 3 to 5 years may be needed for fully stocked, effective windbreaks. Permanent irrigation with a drip system or other irrigation methods can be used to overcome droughtiness. Irrigation allows for healthier, denser, and faster growing windbreaks. Black polypropylene woven fabric can be used to control weeds and conserve moisture after the seedlings are planted. This fabric provides effective weed control within the rows for at least 5 years. It also provides good mulch, which aids in conserving moisture and minimizing extremes in soil temperature.

Farmstead windbreaks protect livestock, buildings, and yards from wind and snow. They also protect fruit trees and gardens and provide habitat for wildlife. Several rows of low- and high-growing broadleaf and coniferous trees and shrubs provide the most protection.

Environmental plantings help to beautify and screen houses and other buildings and to abate noise. The plants, mostly evergreen shrubs and trees, are closely spaced. To insure plant survival, a healthy planting stock of suitable species should be planted properly on a well prepared site and maintained in good condition.

Table 9 shows the height that locally grown trees and shrubs are expected to reach in 20 years on various soils used as cropland. The estimates in the table are based on measurements and observation of established plantings that have been given adequate care. They can be used as a guide in planning windbreaks and screens. Absence of an entry indicates that the soil is either unsuited to growing trees or the trees will not reach the given height unless irrigated. Additional information on planning windbreaks and screens and planting and caring for trees and shrubs can be obtained from the local office of the Natural Resources Conservation Service or of the Cooperative Extension Service or from a commercial nursery.

Each tree or shrub species has certain climatic and physiographic limits. Within these limits, a tree or shrub can be well suited or poorly suited to use in windbreaks because of the soil characteristics. Windbreak suitability groups serve as a guide for selecting the most suitable species for different kinds of soils and for predicting growth and effectiveness. These groups can be used to select plants for windbreaks, recreational and wildlife plantings, ornamental and environmental plantings, reforestation, and critical area plantings.

The soils typically used for irrigated crops have been placed into windbreak suitability groups based on soil properties that effect plant growth. A description of each group and the associated soils are given in the following paragraphs.

Soil Group 3—Loamy

The soils in this group are deep or very deep, loamy, and moderately well drained or well drained. These soils do not have a seasonal high water table within a depth of 36 inches of the surface, and they are not subject to flooding. The available water capacity is 7.0 inches or more. The upper 12 inches does not have free carbonates, has reaction (pH) of as high as 7.8, and is nonsaline. Buckbert, Houstake, and Iris soils are in this group.

Soil Group 5—Droughty

The soils in this group are deep or very deep and are loamy or loamy-skeletal. They are somewhat poorly drained, moderately well drained, or well drained. The water table during the growing season is at a depth of 36 inches or more. The available water capacity is 4 to 7 inches. The upper 12 inches does not have free carbonates, has reaction (pH) of as high as 7.8, and is nonsaline. Lafollette and Plainview soils are in this group.

Soil Group 6—Very Droughty

The soils in this group are moderately deep to very deep; are loamy, loamy-skeletal, sandy, or sandy-skeletal; and are well drained, somewhat excessively drained, or excessively drained. The water table during the growing season is at a depth of 36 inches or more. The available water capacity is 2 to 4 inches. The upper 12 inches does not have free carbonates, has reaction (pH) of as high as 7.8, and is nonsaline. Caphealy and Deskamp soils are in this group.

Soil Group 6R—Moderately Deep, Favorable

The soils in this group are moderately deep; are loamy, clayey-skeletal, or loamy-skeletal; and are somewhat excessively drained or excessively drained. The water table during the growing season is at a depth of 36 inches or more. The available water capacity is 4 inches or more. The upper 12 inches does not have free carbonates, has reaction (pH) of as high as 7.8, and is nonsaline. Agency, Deschutes, Madras, Redmond, and Tumalo soils are in this group.

Soil Group 7—Sandy

The soils in this group are deep or very deep, are sandy throughout, and are moderately well drained, well drained, somewhat excessively drained, or excessively drained. The water table during the growing season is at a depth of 36 inches or more. The available water capacity is 2 inches or more. The upper 12 inches does not have free carbonates, has reaction (pH) of as high as 7.8, and is nonsaline. Clinefalls, Clovkamp, and Tetherow soils are in this group.

Soil Group 8—Loamy, Carbonates

The soils in this group are deep or very deep, loamy, and moderately well drained or well drained. They have a seasonal high water table at a depth of 36 inches or more. The available water capacity is 7 inches or more. The upper 12 inches has reaction (pH) of 7.9 or higher or has electrical conductivity (EC) of as high as 4 millimhos per centimeter. Era soils are in this group.

Soil Group 10—Unsuited

The soils in this group have one or more characteristics, such as depth, texture, drainage, available water capacity, or salts, that severely limit planting, survival, and growth of trees and shrubs. Examples include soils that are very shallow or shallow, soils that have very low available water capacity (less than 2 inches), soils that are very poorly drained or poorly drained and are saturated or ponded throughout the growing season, and soils that have toxic salts. The soils in this group generally are not suited to farmstead, feedlot, or field windbreaks; however, onsite investigation may determine that trees and shrubs can be planted if special treatment, such as irrigation or leaching of salts, is used. The selection of species should be tailored to the conditions of the altered site. Cullius, Gosney, Reuter, Statz, and Stukel soils are in this group.

Recreation

The soils of the survey area are rated in table 10 according to limitations that affect their suitability for recreation. The ratings are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites, and access to public sewer lines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation are also important. Soils subject to flooding are limited for recreational uses by the duration and intensity of flooding and the season when flooding occurs. In planning recreational facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential.

In the table, the degree of soil limitation is expressed as slight, moderate, or severe. *Slight* means that soil properties are generally favorable and that limitations are minor and easily overcome. *Moderate* means that limitations can be overcome or alleviated by planning, design, or special maintenance. *Severe* means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design, intensive maintenance, limited use, or a combination of these measures.

The information in the table can be supplemented by other information in this survey, for example, interpretations for septic tank absorption fields in table 12 and interpretations for dwellings without basements and for local roads and streets in table 11.

Camp areas require site preparation, such as shaping and leveling the tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The best soils have mild slopes and are not wet or subject to flooding during the period of use. The surface has few or no stones or boulders, absorbs rainfall readily but remains firm, and is not dusty when dry. Strong slopes and stones or boulders can greatly increase the cost of constructing campsites.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for picnic areas are firm when wet, are not dusty when dry, are not subject to flooding during the period of use, and do not have slopes or stones or boulders that increase the cost of shaping sites or of building access roads and parking areas.

Playgrounds require soils that can withstand intensive foot traffic. The best soils are almost level and are not wet or subject to flooding during the season of use. The surface is free of stones and boulders, is firm after rains, and is not dusty when dry. If grading is needed, the depth of the soil over bedrock or a hardpan should be considered.

Paths and trails for hiking and horseback riding should require little or no cutting and filling. The best soils are not wet, are firm after rains, are not dusty when dry, and are not subject to flooding more than once a year during the period of use. They have moderate slopes and few or no stones or boulders on the surface.

Golf fairways are subject to heavy foot traffic and some light vehicular traffic. Cutting or filling may be required. The best soils for use as golf fairways are firm when wet, are not dusty when dry, and are not subject to prolonged flooding during the period of use. They have moderate slopes and no stones or boulders on the surface. The suitability of the soil for tees or greens is not considered in rating the soils.

Wildlife Habitat

By Ted Wise, wildlife ecologist, Oregon Department of Fish and Wildlife.

Wildlife habitat is the relationship of animals to plant communities. Animals use the successional stages of plant communities for food, breeding, and cover, including thermal and security cover. Many environmental factors, including soil type, moisture regime, microclimate, slope, elevation, and temperature, affect the animal and plant communities.

Habitat Types

The survey area supports many different habitat types. From west to east, the vegetation includes middle elevation East Cascade Range mixed conifer forests, ponderosa pine and lodgepole pine forests, juniper woodland, and arid areas of grassland sagebrush steppe. The elements of these habitat types and opportunities for enhancement are described briefly in this section.

Forested habitat is comprised of mixed conifers, including Douglas fir, white fir, ponderosa pine, and ponderosa pine-lodgepole pine associations, in varying proportions. Understory plants include snowbrush, manzanita, antelope bitterbrush, squaw currant, squawcarpet, brackenfern, longstolon sedge, Ross sedge, and various grasses and forbs.

Coniferous forest habitat provides thermal and security cover, forage substrate, and seeds. The standing conifer snags (dead trees) provide nesting and roosting habitat for primary excavators (woodpeckers), secondary cavity-nesting birds, and several species of owls that nest in large-diameter bowls in areas where the tops of trees have broken off. Bats also use standing dead trees as roosting sites. Fallen trees in various stages of decay provide necessary habitat for countless invertebrates, small rodents, reptiles, and amphibians. Fire has been a major component in the development of the East Cascade Range forest communities.

Wildlife enhancement practices suited to areas of forest habitat include the creation of forage areas through carefully planned thinnings. Thinning can be done either by mechanical means or by prescribed burning. Thermal and security cover can be improved by planting trees; however, 10 years or more is needed for an area to be partially filled. Trees that are adapted to the particular site characteristics should be planted. Other enhancement practices include maintaining more standing dead trees and large downed trees for use by cavity nesters and small mammals, creating brush piles, and supplementing shrubs with native plantings. Practices used should be carefully planned with clear objectives, and the negative and positive impacts to the wildlife in the area should be considered.

Nonforested rangeland habitat consists of shrubs, grasses, and associated forbs. Antelope bitterbrush, big sagebrush, rabbitbrush, gray horsebrush, bluebunch wheatgrass, western needlegrass, Thurber needlegrass, Idaho fescue, and Sandberg bluegrass are some of the plants associated with this habitat.

Elements of wildlife habitat on sagebrush-shrub rangeland include the shrubs that provide food, nesting areas, and thermal and security cover for animals. Shrubs are important for food in winter because snow may cover lower lying plants. Shrubs also act as shields from chilling winter winds. Wildlife need both forage and cover in close proximity in winter. The native bunchgrasses provide essential cover for newborn birds and the young of larger animals. The grasses and various forbs provide forage in fall, spring, and summer.

Wildlife habitat enhancement practices suited to areas of nonforested rangeland include use of water developments, sound grazing strategies, prescribed burning to achieve a plant community that is a mosaic of plants in seral stages, and seedings and plantings to restore native plant communities. Protection of the soils in these areas should be a top priority. Maintaining the soil base ensures a medium for the growth of plants that are the essence of wildlife habitat.

Riparian habitat consists of vegetation that is dependent on rivers, streams, and springs. More species of wildlife use these areas than any other habitat type. Willows, alders, redosier dogwood, cattails, sedges, and rushes are a few of the riparian-associated plant species.

The elements of riparian habitat vary depending on the soils, topography, and water. Coniferous and deciduous trees are important as thermal, birthing, and loafing cover for animals that are confined to the ground. The trees provide forage for many birds and small animals. Standing dead trees and dead parts of trees provide habitat for primary excavators and secondary cavity-nesting birds. Shrubs and herbaceous plants provide opportunities for nesting and feeding. The grasses in these areas tend to stay greener longer and thus are more palatable during the dry months of the year. The rivers, streams, and springs in these areas provide drinking water for wildlife. Riparian areas serve as important travel corridors and stopover points for many wildlife species during daily and seasonal activities and migrations.

The best way to protect and enhance riparian habitat is to ensure that the resident vegetation is allowed to flourish. Grazing and farming practices should be designed to optimize the existing and potential riparian vegetation. Only in extreme cases is streambank stabilization needed to establish vegetation. Trees such as western juniper and brush can be used to stabilize streambanks. Cuttings and rootstock of resident species from nearby areas can be planted to help restore degraded sites.

Wetland habitat consists of open, marshy or swampy shallow water areas. Riparian communities, which are described in the preceding paragraphs, are one type of wetland habitat. Natural wetland sites are extremely important because artificial developments do not adequately mitigate for natural wetland systems. Pond developments provide habitat for some wetland species if the associated vegetation and varied slopes are maintained and protected. Cattails, sedges, rushes, pondweed, waterlily, elodea, hardstem bullrush, and spikerush are plants associated with wetland areas.

The primary element of wetland habitat is the presence of water on the land for a period of time each year. This allows for natural growth of aquatic vegetation. Marshy areas may include mosaics of open water and emergent vegetation that serves as nesting and feeding areas for waterfowl and other wetland wildlife. Wetland meadows that flood in spring and are dry in summer and fall provide nesting areas for birds and mammals and food for many wildlife species, including deer and elk. Wetland areas attract avian and mammal predators because of the high numbers of other wildlife species that use the habitat. Federal and State laws protect wetland habitat by prohibiting draining and filling. Allowing the vegetation to grow to its full potential is best; thus, practices such as grazing should be avoided in wetland areas. These areas can be enhanced by creating open water areas and nesting islands and by using prescribed burning to create a mosaic of vegetation.

Stream and river habitat consists of the areas where water flows down a channel. It includes instream components such as all sizes of rock fragments and woody debris (logs and brush) that are naturally or artifically placed in the stream or river channel, riparian plant communities, and debris from streamside trees and shrubs.

The elements of stream and river habitat include water flowing in the channel, instream components, and riparian vegetation. The type and amount of instream components occurring naturally in streams and rivers is highly variable. These components affect the velocity and direction of the flow of water and provide cover for aquatic species. Associated riparian habitat helps to maintain the stability of stream and river channels and provides shade and habitat for invertebrates. Suitable enhancement practices for stream and river habitat include maintaining adequate flows for the spawning and rearing of fish. Placement of large logs, root wads, or boulders in the streams can improve the habitat for all species and can influence the flow of water in the channel. Shade can be provided by planting trees and shrubs. Water quality, including regulation of the water temperature, sedimentation, and point and nonpoint toxic waste input, is a concern in stream enhancement.

Agricultural land is used to varying degrees by deer and elk and by pheasant, quail, and various other species of birds. These areas are used mainly as a source of food, although they can also provide valuable cover if properly managed.

Agricultural land provides domestic grains, legumes, and other seed-producing annuals for use as food for wildlife. Grain and seed crops include wheat, barley, oats, rye, millet, and sunflower. Pasture grasses and legumes include alfalfa, clover, sainfoin, orchardgrass, smooth brome, and tall fescue.

Irrigated pasture and farmed areas can be enhanced as habitat for wildlife by maintaining hedgerows and planting the less productive or nonirrigable areas to cover and forage plants. Resting irrigated pastures on a yearly rotation basis provides cover for nesting and wintering animals.

Farm irrigation ponds can be enhanced for wildlife use by fencing out livestock and planting aquatic vegetation that provides food and cover for nesting. Willow cuttings from nearby watercourses can be planted on the banks of ponds along with other trees and shrubs.

Control of exotic weeds may be needed in areas intensively farmed or in areas used as pasture. Care should be taken to avoid adversely impacting other plant species or wildlife.

Fish and Wildlife Species

The survey area supports a wide variety of fish and wildlife species. Some are year-round residents and others occupy the habitat only seasonally.

General soil map units 1, 2, and 3 support lodgepole pine and ponderosa pine forest habitat. These forests provide habitat for mule deer, elk, bear, rabbits, badgers, raccoons, porcupine, bobcats, and coyotes. Larger birds, such as ruffed grouse, goshawk, red-tailed hawk, and great gray owl, use these areas along with black-backed, hairy, and downy woodpeckers and other cavity-dependent birds. The riverine areas in these units provide habitat for rainbow trout, brown trout, whitefish, brook trout, and tui chub. Osprey, kingfishers, mergansers, mallards, and Canada geese nest along the rivers. Mink, beaver, otter, muskrat, and a variety of riparian-dependent passerine birds, smaller mammals, and invertebrates also use these areas. Garter snakes and several species of amphibians live in the areas associated with water.

General soil map units 11, 12, and 13 support drier juniper woodland and sagebrush steppe rangeland habitat. The nonforested rangeland provides habitat for mule deer, coyotes, sage grouse, badgers, antelope, golden eagle, prairie falcon, American kestrel, red-tailed hawk, Swainson’s hawk, and ferrugenous hawk. Marmots, Beldings ground squirrel, brush rabbit, Nuttall cottontail, and black-tailed jackrabbit also use this habitat. Sage thrasher, sage sparrow, western meadowlark, Brewer’s sparrow, and mountain bluebird are some smaller birds that use these areas.

General soil map units 19 and 20 support plant communities that are dominantly ponderosa pine, manzanita, and bitterbrush. Mule deer, elk, cougars, bear, coyotes, and badgers are the larger animals that use these areas. Golden eagle, bald eagle, goshawk, red-tailed hawk, great horned owl, flammulated owl, and screech owl are some of the avian predators that use these areas as habitat. Quail; ruffed grouse; white-headed, hairy, and downy woodpeckers; and many other small birds inhabit areas of these units. Merriam and Rio Grande turkeys are game birds that have been introduced into these units.

General soil map units 15 and 16 support East Cascade Range middle elevation forests. The western areas support mixed conifer habitat, and the lower lying eastern areas support ponderosa pine and bitterbrush plant communities. Wildlife that use areas dominated by conifers include summer-ranging mule deer, elk, black bear, and cougar. Pine marten, badgers, ground squirrels, chipmunks, and a variety of mice, voles, and shrews also use these areas. Raptors including spotted owl, great horned owl, screech owl, flammulated owl, bald eagle, and goshawk use these forested areas. Ruffed grouse, California quail, and introduced turkeys are larger ground birds found in these areas. Chipping sparrow, green-tailed towhee, winter wren, yellow-rumped warbler, red-breasted and white-breasted nuthatches, and a wide variety of other small birds use the habitat in these units. The streams and rivers provide habitat for bull trout, rainbow trout, brown trout, and whitefish. Raccoon, mink, beaver, river otter, and many species of birds use the associated riparian areas.

General soil map units 5, 6, and 17 support western juniper woodland that includes antelope bitterbrush. Progressively lesser amounts of bitterbrush and higher amounts of big sagebrush are present toward the east in these units. The vegetation associated with these units provides habitat for bobcats, coyotes, mule deer, badgers, porcupine, and a number of other smaller mammals. Townsend’s solitaire, black-billed magpie, California quail, northern flicker, mourning dove, mountain bluebird, and dark-eyed junco are a few of the birds in these areas. The Deschutes River corridor provides habitat for rainbow trout, brown trout, whitefish, and tui chub. Avifauna using the habitat associated with the river include golden eagle, bald eagle, osprey, Canada geese, mergansers, mallards, American dipper, yellow warbler, MacGillvary warbler, and rock and canyon wrens. These areas provide winter range for mule deer, although wintering herds have declined as a result of human pressure such as urban growth. Irrigation canals and ponds provide nesting areas for mallards, Brewer’s and red-winged blackbirds, tree frogs, western spadefoot toad, and garter snakes.

General soil map units 4, 7, 8, 9, and 10 support areas of western juniper, bitterbrush, and bunchgrass interspersed with scabland buckwheat flats. Portions of these units have been converted to farmland and pastures. West of the Deschutes River is important winter range for mule deer. Bobcats, coyotes, and a number of burrowing mammals also live in areas of these units. Golden eagle, red-tailed hawk, northern harrier, kestrels, and shrikes are resident raptors. Townsend's solitaire, northern flicker, mountain bluebird, and mountain chickadee are a few of the smaller birds in these areas. Irrigation canals and ponds provide habitat for mallards, Brewer's and red-winged blackbirds, tree frogs, western spadefoot toad, and garter snakes.

General soil map units 14 and 18 support areas of ponderosa pine and bitterbrush, which provide transitory range for herds of Cascade mule deer moving to and from eastern wintering areas. Coyotes, bobcats, marmots, badgers, and rabbits are other mammals that use these areas of ponderosa pine and bitterbrush. Goshawk, red-tailed hawk, Cooper's hawk, flammulated owl, white-headed and black-backed woodpeckers, green-tailed and rufous-sided towhees, Oregon junco, winter wren, chipping sparrow, and yellow-rumped warbler are some of the birds found in these areas.

Engineering

This section provides information for planning land uses related to urban development and to water management. Soils are rated for various uses, and the most limiting features are identified. Ratings are given for building site development, sanitary facilities, construction materials, and water management. The ratings are based on observed performance of the soils and on the estimated data and test data in the "Soil Properties" section.

Information in this section is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil within a depth of 5 or 6 feet. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this section. Local ordinances and regulations should be considered in planning, in site selection, and in design.

Soil properties, site features, and observed performance were considered in determining the ratings in this section. During the fieldwork for this soil survey, determinations were made about grain-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock within 5 or 6 feet of the surface, soil wetness, depth to a seasonal high water table, slope, likelihood of flooding, natural soil structure aggregation, and soil density. Data were collected about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kinds of adsorbed cations. Estimates were made for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, and other behavioral characteristics affecting engineering uses.

This information can be used to evaluate the potential of areas for residential, commercial, industrial, and recreational uses; make preliminary estimates of construction conditions; evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; evaluate alternative sites for sanitary landfills, septic tank absorption fields, and sewage lagoons; plan detailed onsite investigations of soils and geology; locate potential sources of gravel, sand, earthfill, and topsoil; plan drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation; and predict performance of proposed small structures and pavements by comparing the performance of existing similar structures on the same or similar soils.

The information in the tables, along with the soil maps, the soil descriptions, and other data provided in this survey, can be used to make additional interpretations.

Some of the terms used in this soil survey have a special meaning in soil science and are defined in the Glossary.

Building Site Development

Table 11 shows the degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, local roads and streets, and lawns and landscaping. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. Special feasibility studies may be required where the soil limitations are severe.

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for basements, graves, utility lines, open ditches, and other purposes. The ratings are based on soil properties, site features, and observed performance of the soils. The ease of digging, filling, and compacting is affected by the depth to bedrock, a cemented pan, or a very firm dense layer; stone content; soil texture; and slope. The time of the year that excavations can be made is affected by the depth to a seasonal high water table and the susceptibility of the soil to flooding. The resistance of the excavation walls or banks to sloughing or caving is affected by soil texture and depth to the water table.

Dwellings and *small commercial buildings* are structures built on shallow foundations on undisturbed soil. The load limit is the same as that for single-family dwellings no higher than three stories. Ratings are made for small commercial buildings without basements, for dwellings with basements, and for dwellings without basements. The ratings are based on soil properties, site features, and observed performance of the soils. A high water table, flooding, shrinking and swelling, and organic layers can cause the movement of footings. A high water table, depth to bedrock or to a cemented pan, large stones, slope, and flooding affect the ease of excavation and construction. Landscaping and grading that require cuts and fills of more than 5 or 6 feet are not considered.

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material; a base of gravel, crushed rock, or stabilized soil material; and a flexible or rigid surface. Cuts and fills are generally limited to less than 6 feet. The ratings are based on soil properties, site features, and observed performance of the soils. Depth to bedrock or to a cemented pan, a high water table, flooding, large stones, and slope affect the ease of excavating and grading. Soil strength (as inferred from the engineering classification of the soil), shrink-swell potential, frost action potential, and depth to a high water table affect the traffic-supporting capacity.

Lawns and landscaping require soils on which turf and ornamental trees and shrubs can be established and maintained. The ratings are based on soil properties, site features, and observed performance of the soils. Soil reaction, a high water table, depth to bedrock or to a cemented pan, the available water capacity in the upper 40 inches, and the content of salts, sodium, and sulfidic materials affect plant growth. Flooding, wetness, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer affect trafficability after vegetation is established.

Sanitary Facilities

Table 12 shows the degree and kind of soil limitations that affect septic tank absorption fields, sewage lagoons, and sanitary landfills. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required.

The table also shows the suitability of the soils for use as daily cover for landfill. A rating of *good* indicates that soil properties and site features are favorable for the use and good performance and low maintenance can be expected; *fair* indicates that soil properties and site features are moderately favorable for the use and one or more soil properties or site features make the soil less desirable than the soils rated good; and *poor* indicates that one or more soil properties or site features are unfavorable for the use and overcoming the unfavorable properties requires special design, extra maintenance, or costly alteration.

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 24 and 72 inches is evaluated. The ratings are based on soil properties, site features, and observed performance of the soils. Permeability, a high water table, depth to bedrock or to a cemented pan, and flooding affect absorption of the effluent. Large stones and bedrock or a cemented pan interfere with installation.

Unsatisfactory performance of septic tank absorption fields, including excessively slow absorption of effluent, surfacing of effluent, and hillside seepage, can affect public health. Ground water can be polluted if highly permeable sand and gravel or fractured bedrock is less than 4 feet below the base of the absorption field, if slope is excessive, or if the water table is near the surface. There must be unsaturated soil material beneath the absorption field to filter the effluent effectively. Many local ordinances require that this material be of a certain thickness.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons should have a nearly level floor surrounded by cut slopes or embankments of compacted soil. Lagoons generally are designed to hold the sewage within a depth of 2 to 5 feet. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water.

The table gives ratings for the natural soil that makes up the lagoon floor. The surface layer and, generally, 1 or 2 feet of soil material below the surface layer are excavated to provide material for the embankments. The ratings are based on soil properties, site features, and observed performance of the soils. Considered in the ratings are slope, permeability, a high water table, depth to bedrock or to a cemented pan, flooding, large stones, and content of organic matter.

Excessive seepage resulting from rapid permeability in the soil or a water table that is high enough to raise the level of sewage in the lagoon causes a lagoon to function unsatisfactorily. Pollution results if seepage is excessive or if floodwater overtops the lagoon. A high content of organic matter is detrimental to proper functioning of the lagoon because it inhibits aerobic activity. Slope, bedrock, and cemented pans can cause construction problems, and large stones can hinder compaction of the lagoon floor.

Sanitary landfills are areas where solid waste is disposed of by burying it in soil. There are two types of landfill—trench and area. In a trench landfill, the waste is placed in a trench. It is spread, compacted, and covered daily with a thin layer of soil excavated at the site. In an area landfill, the waste is placed in successive layers on the surface of the soil. The waste is spread, compacted, and covered daily with a thin layer of soil from a source away from the site.

Both types of landfill must be able to bear heavy vehicular traffic. Both types involve a risk of ground-water pollution. Ease of excavation and revegetation should be considered.

The ratings in the table are based on soil properties, site features, and observed performance of the soils. Permeability, depth to bedrock or to a cemented pan, a high water table, slope, and flooding affect both types of landfill. Texture, stones and boulders, highly organic layers, soil reaction, and content of salts and sodium affect trench landfills. Unless otherwise stated, the ratings apply only to that part of the soil within a depth of about 6 feet. For deeper trenches, a limitation rated slight or moderate may not be valid. Onsite investigation is needed.

Daily cover for landfill is the soil material that is used to cover compacted solid waste in an area sanitary landfill. The soil material is obtained offsite, transported to the landfill, and spread over the waste.

Soil texture, wetness, coarse fragments, and slope affect the ease of removing and spreading the material during wet and dry periods. Loamy or silty soils that are free of large stones or excess gravel are the best cover for a landfill. Clayey soils are sticky or cloddy and are difficult to spread; sandy soils are subject to wind erosion.

After soil material has been removed, the soil material remaining in the borrow area must be thick enough over bedrock, a cemented pan, or the water table to permit revegetation. The soil material used as the final cover for a landfill should be suitable for plants. The surface layer generally has the best workability, more organic matter, and the best potential for plants. Material from the surface layer should be stockpiled for use as the final cover.

Construction Materials

Table 13 gives information about the soils as a source of roadfill, sand, gravel, and topsoil. The soils are rated *good, fair,* or *poor* as a source of roadfill and topsoil. They are rated as a *probable* or *improbable* source of sand and gravel. The ratings are based on soil properties and site features that affect the removal of the soil and its use as construction material. Normal compaction, minor processing, and other standard construction practices are assumed. Each soil is evaluated to a depth of 5 or 6 feet.

Roadfill is soil material that is excavated in one place and used in road embankments in another place. In this table, the soils are rated as a source of roadfill for low embankments, generally less than 6 feet high and less exacting in design than higher embankments.

The ratings are for the soil material below the surface layer to a depth of 5 or 6 feet. It is assumed that soil layers will be mixed during excavating and spreading. Many soils have layers of contrasting suitability within their profile. The table showing engineering index properties provides detailed information about each soil layer. This information can help to determine the suitability of each layer for use as roadfill. The performance of soil after it is stabilized with lime or cement is not considered in the ratings.

The ratings are based on soil properties, site features, and observed performance of the soils. The thickness of suitable material is a major consideration. The ease of excavation is affected by large stones, a high water table, and slope. How well the soil performs in place after it has been compacted and drained is determined by its strength (as inferred from the engineering classification of the soil) and shrink-swell potential.

Soils rated *good* contain significant amounts of sand or gravel or both. They have at least 5 feet of suitable material, a low shrink-swell potential, few cobbles and stones, and slopes of 15 percent or less. Depth to the water table is more than 3 feet. Soils rated *fair* are more than 35 percent silt- and clay-sized particles and have a plasticity index of less than 10. They have a moderate shrink-swell potential, slopes of 15 to 25 percent, or many stones. Depth to the water table is 1 to 3 feet. Soils rated *poor* have a plasticity index of more than 10, a high shrink-swell potential, many stones, or slopes of more than 25 percent. They are wet and have a water table at a depth of less than 1 foot. They may have layers of suitable material, but the material is less than 3 feet thick.

Sand and *gravel* are natural aggregates suitable for commercial use with a minimum of processing. They are used in many kinds of construction. Specifications for each use vary widely. In the table, only the probability of finding material in suitable quantity is evaluated. The suitability of the material for specific purposes is not evaluated, nor are factors that affect excavation of the material.

The properties used to evaluate the soil as a source of sand or gravel are gradation of grain sizes (as indicated by the engineering classification of the soil), the thickness of suitable material, and the content of rock fragments. Kinds of rock, acidity, and stratification are given in the soil series descriptions. Gradation of grain sizes is given in the table on engineering index properties.

A soil rated as a probable source has a layer of clean sand or gravel or a layer of sand or gravel that is up to 12 percent silty fines. This material must be at least 3 feet thick and less than 50 percent, by weight, large stones. All other soils are rated as an improbable source. Coarse fragments of soft bedrock, such as shale and siltstone, are not considered to be sand and gravel.

Topsoil is used to cover an area so that vegetation can be established and maintained. The upper 40 inches of a soil is evaluated for use as topsoil. Also evaluated is the reclamation potential of the borrow area.

Plant growth is affected by toxic material and by such properties as soil reaction, available water capacity, and fertility. The ease of excavating, loading, and spreading is affected by rock fragments, slope, a water table, soil texture, and thickness of suitable material. Reclamation of the borrow area is affected by slope, a water table, rock fragments, bedrock, and toxic material.

Soils rated *good* have friable, loamy material to a depth of at least 40 inches. They are free of stones and cobbles, have little or no gravel, and have slopes of less than 8 percent. They are low in content of soluble salts, are naturally fertile or respond well to fertilizer, and are not so wet that excavation is difficult.

Soils rated *fair* are sandy soils, loamy soils that have a relatively high content of clay, soils that have only 20 to 40 inches of suitable material, soils that have an appreciable amount of gravel, stones, or soluble salts, or soils that have slopes of 8 to 15 percent. The soils are not so wet that excavation is difficult.

Soils rated *poor* are very sandy or clayey, have less than 20 inches of suitable material, have a large amount of gravel, stones, or soluble salts, have slopes of more than 15 percent, or have a seasonal high water table at or near the surface.

The surface layer of most soils is generally preferred for topsoil because of its organic matter content. Organic matter greatly increases the absorption and retention of moisture and nutrients for plant growth.

Water Management

Table 14 gives information on the soil properties and site features that affect water management. The degree and kind of soil limitations are given for pond reservoir areas and embankments, dikes, and levees. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and are easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increase in construction costs, and possibly increased maintenance are required.

This table also gives for each soil the restrictive features that affect drainage, irrigation, terraces and diversions, and grassed waterways.

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 60 inches. The seepage potential is determined by the permeability of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

Embankments, dikes, and levees are raised structures of soil material, generally less than 20 feet high, constructed to impound water or to protect land against overflow. In this table, the soils are rated as a source of material for embankment fill. The ratings apply to the soil material below the surface layer to a depth of about 5 feet. It is assumed that soil layers will be uniformly mixed and compacted during construction.

The ratings do not indicate the ability of the natural soil to support an embankment. Soil properties to a depth even greater than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties.

Soil material in embankments must be resistant to seepage, piping, and erosion and have favorable compaction characteristics. Unfavorable features include less than 5 feet of suitable material and a high content of stones or boulders, organic matter, or salts or sodium. A high water table affects the amount of usable material. It also affects trafficability.

Drainage is the removal of excess surface and subsurface water from the soil. How easily and effectively the soil is drained depends on the depth to bedrock, to a cemented pan, or to other layers that affect the rate of water movement; permeability; depth to a high water table or depth of standing water if the soil is subject to ponding; slope; susceptibility to flooding; subsidence of organic layers; and the potential for frost action. Excavating and grading and the stability of ditchbanks are affected by depth to bedrock or to a cemented pan, large stones, slope, and the hazard of cutbanks caving. The productivity of the soil after drainage is adversely affected by extreme acidity or by toxic substances in the root zone, such as salts, sodium, and sulfur. Availability of drainage outlets is not considered in the ratings.

Irrigation is the controlled application of water to supplement rainfall and support plant growth. The design and management of an irrigation system are affected by depth to the water table, the need for drainage, flooding, available water capacity, intake rate, permeability, erosion hazard, and slope. The construction of a system is affected by large stones and depth to bedrock or to a cemented pan. The performance of a system is affected by the depth of the root zone, the amount of salts or sodium, and soil reaction.

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to control erosion and conserve moisture by intercepting runoff. Slope, wetness, large stones, and depth to bedrock or to a cemented pan affect the construction of terraces and diversions. A restricted rooting depth, a severe hazard of wind erosion or water erosion, an excessively coarse texture, and restricted permeability adversely affect maintenance.

Grassed waterways are natural or constructed channels, generally broad and shallow, that conduct surface water to outlets at a nonerosive velocity. Large stones, wetness, slope, and depth to bedrock or to a cemented pan affect the construction of grassed waterways. A hazard of wind erosion, low available water capacity, restricted rooting depth, toxic substances such as salts and sodium, and restricted permeability adversely affect the growth and maintenance of the grass after construction.

Soil Properties

Data relating to soil properties are collected during the course of the soil survey. The data and the estimates of soil and water features, listed in tables, are explained on the following pages.

Soil properties are determined by field examination of the soils and by laboratory index testing of some benchmark soils. During the survey, many shallow borings are made and examined to identify and classify the soils and to delineate them on the soil maps. Samples are taken from some typical profiles and tested in the laboratory to determine grain-size distribution, plasticity, and compaction characteristics.

Estimates of soil properties are based on field examinations, on laboratory tests of samples from the survey area, and on laboratory tests of samples of similar soils in nearby areas. Tests verify field observations, verify properties that cannot be estimated accurately by field observation, and help to characterize key soils.

The estimates of soil properties shown in the tables include the range of grain-size distribution and Atterberg limits, the engineering classification, and the physical and chemical properties of the major layers of each soil. Pertinent soil and water features also are given.

Engineering Index Properties

Table 15 gives estimates of the engineering classification and of the range of index properties for the major layers of each soil in the survey area. Most soils have layers of contrasting properties within the upper 5 or 6 feet.

Depth to the upper and lower boundaries of each layer is indicated. The range in depth and information on other properties of each layer are given for each soil series under the heading “Soil Series and Their Morphology.”

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. “Loam,” for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is as much as about 15 percent, an appropriate modifier is added, for example, “gravelly.” Textural terms are defined in the Glossary.

Classification of the soils is determined according to the Unified soil classification system *(4, 16)* and the system adopted by the American Association of State Highway and Transportation Officials *(3, 16)*.

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to grain-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

Rock fragments larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

The estimates of grain-size distribution, liquid limit, and plasticity index are generally rounded to the nearest 5 percent. Thus, if the ranges of gradation and Atterberg limits extend a marginal amount (1 or 2 percentage points) across classification boundaries, the classification in the marginal zone is omitted in the table.

Physical and Chemical Properties

Table 16 shows estimates of some characteristics and features that affect soil behavior. These estimates are given for the major layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each major soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The amount and kind of clay greatly affect the fertility and physical condition of the soil. They determine the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, permeability, plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at $^1/_3$-bar moisture tension. Weight is determined after drying the soil at 105 degrees C. In this table, the estimated moist bulk density of each major soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. A bulk density of more than 1.6 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Permeability refers to the ability of a soil to transmit water or air. The estimates indicate the rate of downward movement of water when the soil is saturated. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Permeability is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each major soil layer. The capacity varies, depending on soil properties that affect the retention of water and the depth of the root zone. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Soil reaction is a measure of acidity or alkalinity and is expressed as a range in pH values. The range in pH of each major horizon is based on many field tests. For many soils, values have been verified by laboratory analyses. Soil reaction is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Shrink-swell potential is the potential for volume change in a soil with a loss or gain in moisture. Volume change occurs mainly because of the interaction of clay minerals with water and varies with the amount and type of clay minerals in the soil. The size of the load on the soil and the magnitude of the change in soil moisture content influence the amount of swelling of soils in place. Swelling was estimated on the basis of the kind and amount of clay minerals in the soil.

If the shrink-swell potential is rated moderate to very high, shrinking and swelling can cause damage to buildings, roads, and other structures. Special design is often needed.

Shrink-swell potential classes are based on the change in length of an unconfined clod as moisture content is increased from air-dry to field capacity. The classes are *low*, a change of less than 3 percent; *moderate*, 3 to 6 percent; *high*, more than 6 percent; and *very high*, greater than 9 percent.

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter (up to 4 percent) and on soil structure and permeability. Values of K range from 0.02

to 0.64. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their resistance to wind erosion in cultivated areas. The groups indicate the susceptibility of soil to wind erosion. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are as follows:

1. Coarse sands, sands, fine sands, and very fine sands.

2. Loamy coarse sands, loamy sands, loamy fine sands, loamy very fine sands, ash material, and sapric soil material.

3. Coarse sandy loams, sandy loams, fine sandy loams, and very fine sandy loams.

4L. Calcareous loams, silt loams, clay loams, and silty clay loams.

4. Clays, silty clays, noncalcareous clay loams, and silty clay loams that are more than 35 percent clay.

5. Noncalcareous loams and silt loams that are less than 20 percent clay and sandy clay loams, sandy clays, and hemic soil material.

6. Noncalcareous loams and silt loams that are more than 20 percent clay and noncalcareous clay loams that are less than 35 percent clay.

7. Silts, noncalcareous silty clay loams that are less than 35 percent clay, and fibric soil material.

8. Soils that are not subject to wind erosion because of coarse fragments on the surface or because of surface wetness.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In the table, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of organic matter in a soil can be maintained or increased by returning crop residue to the soil. Organic matter affects the available water capacity, infiltration rate, and tilth. It is a source of nitrogen and other nutrients for crops.

Soil and Water Features

Table 17 gives estimates of various soil and water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Flooding, the temporary inundation of an area, is caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding.

The table gives the estimated frequency of flooding. It is expressed as none, rare, occasional, and frequent. *None* means that flooding is not probable; *rare* that it is unlikely but possible under unusual weather conditions (the chance of flooding is nearly 0 percent to 5 percent in any year); *occasional* that it occurs, on the average, once or less in 2 years (the chance of flooding is 5 to 50 percent in any year); and *frequent* that it occurs, on the average, more than once in 2 years (the chance of flooding is more than 50 percent in any year).

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and little or no horizon development.

Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

High water table (seasonal) is the highest level of a saturated zone in the soil in most years. The estimates are based mainly on observations of the water table at selected sites and on the evidence of a saturated zone, namely grayish colors or mottles (redoximorphic features) in the soil. Indicated in the table are the depth to the seasonal high water table; the kind of water table—that is, perched, apparent, or artesian; and the months of the year that the water table commonly is high. A water table that is seasonally high for less than 1 month is not indicated in the table.

An *apparent* water table is a thick zone of free water in the soil. It is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil. A *perched* water table is water standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone. An *artesian* water table is under hydrostatic head, generally below an impermeable layer. When this layer is penetrated, the water level rises in an uncased borehole.

Two numbers in the column showing depth to the water table indicate the normal range in depth to a saturated zone. Depth is given to the nearest half foot. The first numeral in the range indicates the highest water level. A plus sign preceding the range in depth indicates that the water table is above the surface of the soil. “More than 6.0” indicates that the water table is below a depth of 6 feet or that it is within a depth of 6 feet for less than a month.

Depth to bedrock is given if bedrock is within a depth of 5 feet. The depth is based on many soil borings and on observations during soil mapping. The rock is either soft or hard. If the rock is soft or fractured, excavations can be made with trenching machines, backhoes, or small rippers. If the rock is hard or massive, blasting or special equipment generally is needed for excavation.

A *cemented pan* is a cemented or indurated subsurface layer within a depth of 5 feet. Such a pan causes difficulty in excavation. Pans are classified as thin or thick. A thin pan is less than 3 inches thick if continuously indurated or less than 18 inches thick if discontinuous or fractured. Excavations can be made by trenching machines, backhoes, or small rippers. A thick pan is more than 3 inches thick if continuously indurated or more than 18 inches thick if discontinuous or fractured. Such a pan is so thick or massive that blasting or special equipment is needed in excavation.

Potential frost action is the likelihood of upward or lateral expansion of the soil caused by the formation of segregated ice lenses (frost heave) and the subsequent collapse of the soil and loss of strength on thawing. Frost action occurs when moisture moves into the freezing zone of the soil. Temperature, texture, density, permeability, content of organic matter, and depth to the water table are the most important factors considered in evaluating the potential for frost action. It is assumed that the soil is not insulated by vegetation or snow and is not artificially drained. Silty and highly structured, clayey soils that have a high water table in winter are the most susceptible to frost action. Well drained, very gravelly, or very sandy soils are the least susceptible. Frost heave and low soil strength during thawing cause damage mainly to pavements and other rigid structures.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than steel in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low, moderate,* or *high,* is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion is also expressed as *low, moderate,* or *high*. It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories *(25, 26)*. Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. Table 18 shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

ORDER. Eleven soil orders are recognized. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in *sol*. An example is Andisol.

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Xerand (*Xer*, meaning dry, plus *and*, from Andisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; type of saturation; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Vitrixerands (*Vitri*, meaning glass, plus *xerand*, the suborder of the Andisols that has a xeric moisture regime).

SUBGROUP. Each great group has a typic subgroup. Other subgroups are intergrades or extragrades. The typic subgroup is the central concept of the great group; it is not necessarily the most extensive. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group but do not indicate transitions to any other taxonomic class. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Typic* identifies the subgroup that typifies the great group. An example is Typic Vitrixerands. An example of an intergrade subgroup is Humic Vitrixerands. The adjective *Humic*, meaning humus, indicates that the surface layer is enriched with organic matter.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Generally, the properties are those of horizons below plow depth where there is much biological activity. Among the properties and characteristics considered are particle size, mineral content, soil temperature regime, soil depth, and reaction. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is ashy over loamy, mixed, frigid Humic Vitrixerands.

SERIES. The series consists of soils within a family that have horizons similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile.

Soil Series and Their Morphology

In this section, each soil series recognized in the survey area is described. Characteristics of the soil and the material in which it formed are identified for each series. A pedon, a small three-dimensional area of soil, that is typical of the series in the survey area is described. The detailed description of each soil horizon follows standards in the “Soil Survey Manual” *(22)*. Many of the technical terms used in the descriptions are defined in “Soil Taxonomy” *(25)* and in “Keys to Soil Taxonomy” *(26)*. Unless otherwise indicated, colors in the descriptions are for dry soil. Following the pedon description is the range of important characteristics of the soils in the series.

The map units of each soil series are described in the section “Detailed Soil Map Units.”

Agency Series

The Agency series consists of moderately deep, well drained soils on lava plains and hills. These soils formed in loess over volcaniclastic sediment of the Deschutes Formation. Slopes are 0 to 15 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Agency loam, 0 to 3 percent slopes; 1,500 feet south and 600 feet west of the southeast corner of the NE¹/₄ of sec. 26, T. 9 S., R. 13 E.

Ap1—0 to 4 inches; grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; moderate fine granular structure; slightly hard, friable, slightly sticky and nonplastic; many very fine, fine, medium, and coarse roots; many very fine interstitial pores; neutral (pH 6.8); clear wavy boundary.

Ap2—4 to 8 inches; grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; massive; slightly hard, friable, slightly sticky and nonplastic; few very fine roots; many very fine tubular pores; neutral (pH 6.8); clear wavy boundary.

AB—8 to 16 inches; brown (10YR 5/3) loam, dark brown (10YR 3/3) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and nonplastic; few very fine roots; many very fine tubular pores; mildly alkaline (pH 7.6); clear wavy boundary.

Bw1—16 to 24 inches; pale brown (10YR 6/3) loam, dark brown (10YR 3/3) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and nonplastic; few very fine roots; many very fine tubular pores; mildly alkaline (pH 7.6); gradual wavy boundary.

Bw2—24 to 29 inches; pale brown (10YR 6/3) cobbly loam, brown (10YR 4/3) moist; weak fine subangular blocky structure; hard, friable, slightly sticky and nonplastic; many very fine interstitial pores; 5 percent gravel and 10 percent cobbles; coatings of lime on underside of gravel and cobbles; moderately alkaline (pH 8.0); clear wavy boundary.

2Crkq—29 to 33 inches; weathered tuff with coatings of silica and calcium carbonate along fractures; moderately effervescent; clear wavy boundary.

2R—33 inches; welded tuff of the Deschutes Formation.

Depth to bedrock, consisting of basalt or tuff, is 22 to 40 inches. The particle-size control section averages 18 to 27 percent clay.

The A horizon has hue of 10YR, value of 5 when dry and 3 when moist, and chroma of 2 or 3 when moist or dry. The horizon is sandy loam or loam. It is neutral or mildly alkaline.

The Bw horizon has hue of 10YR, value of 6 when dry and 3 or 4 when moist, and chroma of 3 or 4 when moist or dry. The horizon is loam, clay loam, cobbly loam, or cobbly clay loam and is 15 to 30 percent clay. It is 0 to 20 percent gravel and 0 to 25 percent cobbles. Total rock fragment content is 5 to 30 percent. The horizon is mildly alkaline or moderately alkaline.

The 2Crkq horizon, where present, is weathered tuff of the Deschutes Formation.

Allingham Series

The Allingham series consists of well drained soils that are moderately deep to glacial outwash. These soils are on outwash plains. They formed in ash over glacial outwash. Slopes are 0 to 30 percent. The mean annual precipitation is about 25 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Allingham gravelly sandy loam in an area of Allingham-Circle complex, 0 to 15 percent slopes; 50 feet south of Forest Service Road 1425, opposite intersection of Forest Service Road 600; in the SW¹/₄SW¹/₄ of sec. 33, T. 12 S., R. 9 E.

Oi—1 inch to 0; litter of needles, leaves, and twigs from ponderosa pine, antelope bitterbrush, and manzanita.

A1—0 to 4 inches; very dark grayish brown (10YR 3/2) gravelly sandy loam, brown (10YR 4/3) dry; moderate fine granular structure; slightly hard, friable, nonsticky and nonplastic; few medium roots and common very fine and fine roots; many very fine interstitial pores and many fine vesicular pores; 20 percent rounded gravel; slightly acid (pH 6.1); gradual smooth boundary.

A2—4 to 8 inches; dark brown (10YR 3/3) gravelly sandy loam, dark yellowish brown (10YR 4/4) dry; weak fine subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few fine and medium roots and common very fine roots; common very fine interstitial pores and common fine vesicular pores; 20 percent rounded gravel; slightly acid (pH 6.4); gradual wavy boundary.

A3—8 to 16 inches; dark brown (10YR 3/3) gravelly sandy loam, dark yellowish brown (10YR 4/4) dry; weak fine and medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few very fine, fine, and medium roots; common very fine interstitial pores and few fine vesicular pores; 20 percent rounded gravel; neutral (pH 6.6); clear irregular boundary.

2Bwb—16 to 28 inches; dark brown (7.5YR 3/4) loam, yellowish brown (10YR 5/6) dry; weak medium and coarse subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few very fine and fine roots; common very fine interstitial pores; 10 percent rounded gravel; neutral (pH 7.0); clear wavy boundary.

3Btb1—28 to 42 inches; dark yellowish brown (10YR 3/6) very gravelly clay loam, yellowish brown (10YR 5/4) dry; weak very coarse subangular blocky structure; hard, firm, slightly sticky and slightly plastic; few very fine and fine roots; many very fine interstitial pores; common iron and manganese coatings on peds; common faint clay films on peds and in pores; 30 percent rounded gravel and 10 percent rounded cobbles; neutral (pH 7.0); gradual wavy boundary.

3Btb2—42 to 65 inches; dark yellowish brown (10YR 3/6) very cobbly clay loam, dark yellowish brown (10YR 3/6) dry; weak very coarse subangular blocky structure; hard, firm, slightly sticky and slightly plastic; few very fine roots; many very fine interstitial pores; common faint clay films on peds and in pores; 20 percent rounded gravel and 30 percent rounded cobbles; neutral (pH 6.8).

Depth to the buried glacial outwash material (3Btb horizon) is 20 to 40 inches. Depth to bedrock is more than 60 inches.

The O horizon is 1 to 3 inches thick except in areas that have been disturbed.

The A horizon has hue of 10YR when moist or dry, value of 2 or 3 when moist and 4 or 5 when dry, and chroma of 2 or 3 when moist and 3 or 4 when dry. The horizon is 5 to 15 percent clay and 15 to 30 percent rounded gravel. It is slightly acid or neutral.

The 2Bwb horizon has hue of 7.5YR or 10YR when moist and 10YR when dry, value of 3 when moist and 5 when dry, and chroma of 3 or 4 when moist and 6 when dry. The horizon is 15 to 27 percent clay and 5 to 15 percent rounded gravel. It is slightly acid or neutral.

The 3Btb horizon has hue of 10YR when moist or dry, value of 3 when moist and 3 to 5 when dry, and chroma of 6 when moist and 4 to 6 when dry. The horizon is very gravelly and very cobbly loam or clay loam. It is 20 to 35 percent clay. It is 15 to 30 percent rounded gravel and 10 to 35 percent rounded cobbles. Total rock fragment content is 35 to 60 percent. The horizon is neutral or mildly alkaline.

Aquolls

Aquolls consist of very deep, poorly drained soils in basins. These soils formed in lacustrine sediment. Slopes are 0 to 1 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 48 degrees F.

Representative pedon of Aquolls, 0 to 1 percent slopes; 1,000 feet east and 20 feet north of the southwest corner of sec. 21, T. 13 S., R. 11 E.

A1—0 to 3 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak thin platy structure; slightly hard, friable, nonsticky and nonplastic; many very fine roots; many very fine interstitial pores; neutral (pH 7.0); clear smooth boundary.

A2—3 to 11 inches; black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; weak fine granular structure; slightly hard, friable, sticky and slightly plastic; common very fine roots; many very fine interstitial pores; neutral (pH 7.2); clear wavy boundary.

2C1—11 to 20 inches; very dark gray (10YR 3/1) silt loam, grayish brown (10YR 5/2) dry; few distinct dark yellowish brown (10YR 4/4 and 4/6) mottles; massive; slightly hard, firm, sticky and nonplastic; few medium roots; many fine interstitial pores; few iron concretions; neutral (pH 7.2); clear smooth boundary.

3C2—20 to 60 inches; dark grayish brown (10YR 4/2) silty clay, grayish brown (10YR 5/2) dry; common distinct grayish brown (10YR 5/2) mottles; massive; hard, very firm, sticky and plastic; few fine tubular pores; neutral (pH 7.2).

Depth to bedrock is more than 60 inches.

The A horizon has value of 4 or 5 when dry, and it has chroma of 1 or 2 when moist or dry.

The 2C horizon has value of 4 or 5 when dry, and it has chroma of 1 or 2 when moist or dry. The horizon is silt loam or silty clay loam.

The 3C horizon has chroma of 1 to 3 when moist or dry. It is silty clay or silty clay loam.

Bakeoven Series

The Bakeoven series consists of very shallow, well drained soils on hills and lava plains. These soils formed in residuum. Slopes are 0 to 3 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Bakeoven very cobbly loam in area of Bakeoven-Agency-Madras complex, 0 to 3 percent slopes; 200 feet west and 200 feet south of the northeast corner of sec. 25, T. 12 S., R. 11 E.

A—0 to 2 inches; brown (10YR 5/3) very cobbly loam, very dark grayish brown (10YR 3/2) moist; weak thin platy structure; slightly hard, friable, slightly sticky and nonplastic; few very fine roots; many very fine and few fine vesicular pores; 10 percent gravel, 30 percent cobbles, and 15 percent stones; neutral (pH 7.2); clear smooth boundary.

Bw1—2 to 5 inches; brown (10YR 5/3) very gravelly loam, dark brown (10YR 3/3) moist; weak thin platy structure; slightly hard, very friable, slightly sticky and nonplastic; few very fine roots; many very fine interstitial pores; 40 percent gravel; mildly alkaline (pH 7.4); clear wavy boundary.

Bw2—5 to 6 inches; brown (10YR 5/3) very gravelly loam, dark brown (10YR 3/3) moist; weak fine subangular blocky structure; slightly hard, very friable, slightly sticky and nonplastic; few very fine, fine, and medium roots; many very fine interstitial pores; 45 percent gravel; mildly alkaline (pH 7.4); clear wavy boundary.

2R—6 inches; basalt.

Depth to bedrock is 4 to 10 inches. The profile is neutral or mildly alkaline.

The A horizon has value 4 or 5 when dry and 2 or 3 when moist, and it has chroma of 2 or 3 when moist or dry. It is 0 to 20 percent gravel, 30 to 50 percent cobbles, and 0 to 15 percent stones. Total rock fragment content is 35 to 60 percent.

The Bw horizon has value of 4 or 5 when dry and 2 or 3 when moist, and it has chroma of 2 or 3 when moist or dry. It is very gravelly clay loam, very cobbly loam, or very gravelly loam.

Beden Series

The Beden series consists of shallow, well drained soils on lava plains and hills. These soils formed in residuum derived from basalt with ash in the upper part. Slopes are 0 to 50 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Beden stony sandy loam, 0 to 10 percent slopes; about 300 feet west and 300 feet south of the northeast corner of sec. 7, T. 22 S., R. 19 E.

A1—0 to 5 inches; very dark grayish brown (10YR 3/2) stony sandy loam, grayish brown (10YR 3/2) dry; weak medium platy structure parting to weak fine granular; slightly hard, friable, slightly sticky and nonplastic; many very fine roots; many fine vesicular pores; 5 percent gravel, 5 percent cobbles, and 10 percent stones; neutral (pH 7.0); clear wavy boundary.

A2—5 to 11 inches; dark brown (10YR 3/3) stony sandy loam, brown (10YR 5/3) dry; weak fine granular structure; slightly hard, friable, slightly sticky and nonplastic; common very fine, fine, and medium roots; few very fine and fine tubular pores; 5 percent gravel, 5 percent cobbles, and 10 percent stones; neutral (pH 7.2); clear wavy boundary.

2Bt1—11 to 15 inches; brown (10YR 5/3) loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common fine and medium roots; few very fine tubular pores; few faint clay films on faces of peds and in pores; 10 percent gravel; mildly alkaline (pH 7.4); abrupt wavy boundary.

2Bt2—15 to 18 inches; brown (10YR 5/3) clay loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky structure; hard, very firm, sticky and plastic; few fine and medium roots; few very fine tubular pores; common faint clay films on faces of peds and in pores; 10 percent gravel; mildly alkaline (pH 7.6); abrupt wavy boundary.

2R—18 inches; fractured basalt with a thin, discontinuous coating of opal on the surface.

Depth to bedrock is 10 to 20 inches.

The A horizon has value of 2 or 3 when moist and 4 or 5 when dry, and it has chroma of 2 or 3 when moist or dry. The horizon is sandy loam or stony sandy loam and is 5 to 15 percent clay. It is 0 to 15 percent gravel and 0 to 15 percent cobbles and stones. The horizon is 5 to 20 percent volcanic ash.

The 2Bt horizon has value of 3 or 4 when moist and 5 or 6 when dry, and it has chroma of 3 or 4 when moist or dry. It is loam, clay loam, gravelly loam, or gravelly clay loam and is 18 to 35 percent clay. The horizon is 5 to 25 percent gravel and 0 to 10 percent cobbles. It is neutral or mildly alkaline.

Belrick Series

The Belrick series consists of very deep, well drained soils on moraines. These soils formed in ash over glacial till. Slopes are 0 to 50 percent. The mean annual precipitation is about 60 inches, and the mean annual air temperature is about 40 degrees F.

Typical pedon of Belrick fine sandy loam, 15 to 30 percent slopes, on Forest Service Road 1210-300; 100 feet east and 500 feet north of the northwest corner of the SW1/4 of sec. 14, T. 13 S., R. 8 E.

Oi—1 inch to 0; litter of Douglas fir, white fir, and ponderosa pine needles and twigs and vine maple leaves.

A1—0 to 3 inches; very dark brown (10YR 2/2) fine sandy loam, dark brown (10YR 3/3) dry; weak fine granular structure; slightly hard, friable, nonsticky and nonplastic; many very fine and fine roots and few medium and coarse roots; many very fine interstitial pores; 2 percent subrounded gravel; neutral (pH 6.8); clear wavy boundary.

A2—3 to 11 inches; very dark brown (10YR 2/2) fine sandy loam, dark yellowish brown (10YR 4/4) dry; weak medium granular structure; slightly hard, friable, nonsticky and nonplastic; few medium and coarse roots and common very fine and fine roots; many very fine interstitial pores; neutral (pH 6.8); gradual wavy boundary.

A3—11 to 16 inches; very dark brown (10YR 2/2) fine sandy loam, dark yellowish brown (10YR 3/4) dry; weak fine subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few very fine, fine, medium, and coarse roots; many very fine interstitial pores; neutral (pH 7.2); gradual irregular boundary.

2C—16 to 24 inches; mixed black and very dark brown (10YR 2/1 and 2/2) loamy fine sand and fine sand, very dark grayish brown and dark brown (10YR 3/2 and 3/3) dry; massive; loose, nonsticky and nonplastic; few very fine, fine, medium, and coarse roots; many very fine interstitial pores; few weakly cemented nodules; neutral (pH 7.2); clear wavy boundary.

3Bwb—24 to 65 inches; dark yellowish brown (10YR 3/4) extremely stony sandy loam, yellowish brown (10YR 5/4) dry; weak fine subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; few fine, medium, and coarse roots; many fine interstitial pores and few fine and medium tubular pores; 15 percent subrounded gravel, 20 percent subrounded cobbles, and 30 percent subrounded stones; neutral (pH 7.2).

Depth to the buried glacial till material (3Bwb horizon) is 20 to 40 inches. Depth to bedrock is more than 60 inches.

The O horizon is 1 to 3 inches thick except in areas that have been disturbed.

The A horizon has hue of 10YR, value of 2 or 3 when moist and 3 or 4 when dry, and chroma of 2 or 3 when moist and 3 or 4 when dry. The horizon is 5 to 15 percent clay and 0 to 5 percent subrounded gravel. It is slightly acid or neutral.

The 2C horizon has hue of 10YR, value of 2 or 3 when moist and 3 or 4 when dry, and chroma of 1 or 2 when moist and 2 to 4 when dry. The horizon is mixed or stratified loamy fine sand and fine sand or is fine sandy loam. It is 5 to 15 percent clay and 0 to 5 percent subrounded gravel. The horizon is slightly acid or neutral. It has a layer of black scoria is in some pedons.

The 3Bwb horizon has hue of 10YR, value of 3 when moist and 4 or 5 when dry, and chroma of 4 when moist or dry. It is very stony or extremely stony loam or sandy loam. The horizon is 10 to 20 percent subrounded gravel, 10 to 20 percent subrounded cobbles, and 15 to 30 percent subrounded stones. Total rock fragment content is 35 to 70 percent. The horizon is 10 to 25 percent clay.

Blayden Series

The Blayden series consists of well drained soils that are shallow to a duripan. These soils are on lava plains. They formed in old alluvium capped with ash. Slopes are 0 to 3 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Blayden loamy sand, 0 to 3 percent slopes; about 300 feet south and 300 feet west of the northeast corner of the SE1/4 of sec. 5, T. 20 S., R. 16 E.

A1—0 to 3 inches; grayish brown (10YR 5/2) loamy sand, dark brown (10YR 3/3) moist; moderate thick platy structure; soft, very friable, nonsticky and nonplastic; common very fine and fine roots; many very fine vesicular pores; 5 percent gravel; neutral (pH 7.2); clear wavy boundary.

2A2—3 to 7 inches; brown (10YR 5/3) gravelly loam, dark brown (10YR 3/3) moist; moderate fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine and few fine roots; many very fine tubular pores; 20 percent gravel; mildly alkaline (pH 7.6); clear smooth boundary.

2Bt—7 to 15 inches; pale brown (10YR 6/3) gravelly loam, dark yellowish brown (10YR 3/4) moist; moderate medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few fine roots; common very fine tubular pores; few faint clay films on peds and in pores; 30 percent gravel; mildly alkaline (pH 7.8); abrupt smooth boundary.

3Bkqm—15 to 60 inches; pale brown (10YR 6/3) indurated gravelly duripan, dark yellowish brown (10YR 4/4) moist; carbonates occur as coatings on rock fragments or as filaments; violently effervescent; moderately alkaline (pH 8.0).

Depth to the duripan is 12 to 20 inches. Depth to bedrock is more than 60 inches. The duripan consists of stratified sand and gravel. The mollic epipedon is 7 to 11 inches thick.

The A horizon has value of 3 when moist and 5 when dry, and it has chroma of 2 or 3 when moist or dry. The horizon is 5 to 25 percent gravel. The upper part is 2 to 10 percent clay, and the lower part is 10 to 20 percent clay.

The 2Bt horizon has value of 3 or 4 when moist and 5 or 6 when dry, and it has chroma of 3 or 4 when moist or dry. The horizon is gravelly loam, gravelly clay loam, or gravelly sandy clay loam and is 10 to 35 percent gravel and 25 to 35 percent clay. It is mildly alkaline or moderately alkaline.

Bluesters Series

The Bluesters series consists of excessively drained soils that are shallow to cinders. These soils are on cinder cones. They formed in ash over cinders. Slopes are 15 to 50 percent. The mean annual precipitation is about 15 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Bluesters gravelly sandy loam, 15 to 50 percent slopes; on the east side of Henkle Butte; 1,000 feet east of the southwest corner of sec. 24, T. 14 S., R. 10 E.

A1—0 to 4 inches; dark brown (10YR 3/3) gravelly sandy loam, dark yellowish brown (10YR 4/4) dry; weak fine granular structure; slightly hard, friable, nonsticky and nonplastic; common fine and medium roots and many very fine roots; many very fine irregular pores; 20 percent angular gravel; neutral (pH 7.0); gradual wavy boundary.

A2—4 to 16 inches; dark brown (7.5YR 3/2) gravelly sandy loam, brown (7.5YR 5/4) dry; weak fine granular structure; slightly hard, friable, nonsticky and nonplastic; common very fine roots and few fine, medium, and coarse roots; many very fine irregular pores; 30 percent angular gravel; neutral (pH 7.0); clear wavy boundary.

2C—16 to 60 inches; cinders that are black (N 2/0) and dark reddish brown (5YR 3/4) moist or dry; single grain; loose, nonsticky and nonplastic; common very fine roots and few fine, medium, and coarse roots; many fine vesicular pores; less than 10 percent of voids filled; neutral (pH 7.0).

Depth to bedrock is more than 60 inches. Depth to cinders is 14 to 30 inches.

The A horizon has hue of 7.5YR or 10YR, value of 2 or 3 when moist and 4 or 5 when dry, and chroma of 2 or 3 when moist and 4 when dry. It is 15 to 35 percent basaltic gravel-sized cinders and 20 percent pumice sand (0.5 to 2.0 millimeters).

The 2C horizon has hue of 5YR, 7.5YR, or 10YR or is neutral. It has value of 2, 3, 5, 6, or 7 when moist or dry and chroma of 0, 4, or 8 when moist or dry. The horizon is 80 to 100 percent gravel-sized cinders.

Borobey Series

The Borobey series consists of very deep and deep, somewhat excessively drained soils on lava plains. These soils formed in ash over old alluvium. Slopes are 0 to 5 percent. The mean annual precipitation is about 11 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Borobey sandy loam, 0 to 5 percent slopes; 900 feet south of U.S. Highway 20, in the NW$^1/_4$NW$^1/_4$NW$^1/_4$ of sec. 12, T. 20 S., R. 16 E.

A—0 to 4 inches; grayish brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) moist; weak thick platy structure; slightly hard, friable, slightly sticky and nonplastic; many very fine roots; many fine and medium irregular pores; about 30 percent ash; neutral; clear smooth boundary.

AB—4 to 21 inches; brown (10YR 5/3) sandy loam, dark brown (10YR 3/3) moist; massive; soft, very friable, slightly sticky and nonplastic; common very fine roots; many fine and medium irregular pores; about 40 percent ash; neutral; clear wavy boundary.

Bq—21 to 51 inches; pale brown (10YR 6/3) sandy loam, dark yellowish brown (10YR 3/4) moist; moderate fine subangular blocky structure; hard, firm and brittle, slightly sticky and slightly plastic; few very fine roots; common very fine tubular pores; about 40 percent ash; neutral; abrupt smooth boundary.

2Bwb—51 to 60 inches; pale brown (10YR 6/3) clay loam, dark yellowish brown (10YR 3/4) moist; moderate fine subangular blocky structure; hard, firm, sticky and plastic; few very fine roots; common very fine tubular pores; neutral.

Depth to the brittle layer is 20 to 40 inches. Depth to bedrock is more than 60 inches. Depth to a strongly cemented or indurated duripan is 40 to 60 inches or more.

The A and AB horizons have chroma of 2 or 3 when moist or dry. They are 0 to 25 percent gravel. The horizons are sandy loam or gravelly sandy loam with a thin layer of loamy sand in some pedons.

The Bq horizon has value of 5 or 6 when dry and 3 or 4 when moist, and it has chroma of 3 or 4 when moist or dry. The horizon is sandy loam or loamy sand and is 5 to 15 percent clay and 55 to 80 percent sand. It is neutral to moderately alkaline. The horizon is 0 to 25 percent gravel.

The 2Bwb horizon, where present, is loam or clay loam and is 15 to 30 percent clay. It is neutral to moderately alkaline.

Bott Series

The Bott series consists of very deep, well drained soils on mountains. These soils formed in ash over colluvium. Slopes are 0 to 50 percent. The mean annual precipitation is about 60 inches, and the mean annual air temperature is about 40 degrees F.

Typical pedon of Bott gravelly sandy loam in an area of Bott-Douthit complex, 15 to 30 percent slopes; on Forest Service Road 1200-860; 300 feet north and 200 feet west of the southeast corner of sec. 7, T. 12 S., R. 9 E.

Oi—1 inch to 0; litter of Douglas fir and white fir needles and twigs.

A1—0 to 10 inches; dark yellowish brown (10YR 3/4) gravelly sandy loam, yellowish brown (10YR 5/4) dry; moderate fine granular structure; slightly hard, friable, nonsticky and slightly plastic; many very fine and fine roots and few medium roots; many very fine irregular pores; 15 percent subrounded gravel; 25 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.0); gradual wavy boundary.

A2—10 to 23 inches; dark yellowish brown (10YR 3/4) sandy loam, yellowish brown (10YR 5/6) dry; weak fine subangular blocky structure parting to single grain; slightly hard, friable, nonsticky and nonplastic; many very fine and fine roots and few medium and coarse roots; many very fine irregular pores; 10 percent subrounded gravel; 20 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.0); clear wavy boundary.

2Btb—23 to 62 inches; dark brown (10YR 3/3) very stony loam, brown (10YR 5/3) dry; strong fine and medium subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; common very fine roots and few fine, medium, and coarse roots; common fine vesicular pores and few fine tubular pores; common distinct clay films on peds and in pores; 20 percent subrounded gravel, 10 percent cobbles, and 25 percent subrounded and angular stones; neutral (pH 7.0).

Depth to bedrock is more than 60 inches. Depth to the buried soil material is 20 to 30 inches. It is 10 to 20 percent clay.

The O horizon is 1 to 3 inches thick except in areas that have been disturbed.

The A horizon has hue of 10YR or 7.5YR and value of 3 when moist and 5 when dry. The upper part of the horizon has chroma of 4 when moist or dry, and the lower part has chroma of 4 when moist and 5 or 6 when dry. The horizon is 5 to 25 percent gravel. It is sandy loam or gravelly sandy loam.

The 2Btb horizon has hue of 10YR or 7.5YR, value of 3 when moist and 5 when dry, and chroma of 3 or 4 when moist or dry. It is 15 to 25 percent gravel, 5 to 15 percent cobbles, and 15 to 30 percent stones. Total rock fragment content is 35 to 60 percent.

Buckbert Series

The Buckbert series consists of very deep, well drained soils in swales on hills. These soils formed in ash over alluvium. Slopes are 0 to 3 percent. The mean annual precipitation is about 11 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Buckbert sandy loam, 0 to 3 percent slopes; 1,000 feet south and 100 feet west of the northeast corner of the NW$^1/_4$ of sec. 17, T. 14 S., R. 12 E.

Ap—0 to 8 inches; brown (10YR 5/3) sandy loam, very dark grayish brown (10YR 3/2) moist; weak medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few very fine roots; common very fine irregular pores; neutral (pH 6.8); gradual smooth boundary.

AB—8 to 21 inches; brown (10YR 5/3) sandy loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few very fine irregular pores; neutral (pH 7.2); gradual wavy boundary.

Bw1—21 to 40 inches; pale brown (10YR 6/3) loam, dark brown (10YR 4/3) moist; weak coarse subangular blocky structure; slightly hard, friable, slightly sticky and nonplastic; few very fine irregular pores; 5 percent pumice gravel; mildly alkaline (pH 7.6); abrupt wavy boundary.

Bw2—40 to 52 inches; light yellowish brown (10YR 6/4) loam, dark brown (7.5YR 4/4) moist; many medium distinct very dark grayish brown mottles; weak coarse subangular blocky structure; hard, firm, nonsticky and nonplastic; few fine tubular pores; 5 percent pumice gravel; mildly alkaline (pH 7.6); clear wavy boundary.

C—52 to 60 inches; yellowish brown (10YR 5/4) sandy loam, dark brown (10YR 3/3) moist; massive; slightly hard, friable, nonsticky and nonplastic; few fine tubular pores; mildly alkaline (pH 7.6).

Depth to bedrock is 60 inches or more.

The A and AB horizons have hue of 10YR, value of 2 or 3 when moist and 5 when dry, and chroma of 2 or 3 when moist or dry.

The Bw horizon has hue of 10YR, value of 3 or 4 when moist and 5 or 6 when dry, and chroma of 3 or 4 when moist or dry. It is 0 to 10 percent gravel-sized pumice and 15 to 25 percent clay.

The C horizon has hue of 7.5YR or 10YR, value of 3 or 4 when moist and 5 or 6 when dry, and chroma of 3 or 4 when moist and 4 when dry. It is 0 to 10 percent gravel-sized pumice. Faint to distinct mottles are in most pedons as a result of irrigation. The horizon is sandy loam or loam and is 10 to 20 percent clay.

Caphealy Series

The Caphealy series consists of moderately deep, well drained soils on hills. These soils formed in colluvium over volcaniclastic sediment of the Deschutes Formation. Slopes are 0 to 30 percent slopes. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Caphealy sandy loam in an area of Caphealy-Reuter complex, 15 to 30 percent slopes; on the east side of roadcut; 200 feet north and 1,000 feet west of the southeast corner of the northwest corner of sec. 36, T. 12 S., R. 12 E.

A1—0 to 2 inches; grayish brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; slightly hard, friable, nonsticky and nonplastic; many very fine and fine roots and few medium roots; many very fine interstitial pores; 5 percent gravel; neutral (pH 7.2); clear smooth boundary.

A2—2 to 16 inches; brown (10YR 5/3) sandy loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few very fine and fine roots; many very fine tubular pores; 2 percent gravel; mildly alkaline (pH 7.8); gradual smooth boundary.

Bw—16 to 19 inches; brown (10YR 5/3) coarse sandy loam, dark yellowish brown (10YR 3/4) moist; weak medium subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; few very fine and fine roots; many very fine interstitial pores; 10 percent gravel; moderately alkaline (pH 8.0); clear smooth boundary.

2Bk—19 to 23 inches; brown (10YR 5/3) gravelly coarse sand, dark yellowish brown (10YR 3/4) moist; single grain; loose, nonsticky and nonplastic; many very fine interstitial pores; 30 percent gravel; coatings of calcium carbonate on underside of coarse fragments; moderately alkaline (pH 8.0); gradual broken boundary.

3Crkq—23 to 26 inches; weathered, fractured tuff with discontinuous veins of silica and calcium carbonate; clear wavy boundary.

3R—26 inches; welded tuff of the Deschutes Formation.

The paralithic contact is at a depth of 20 to 38 inches, and it is underlain by hard bedrock. The profile is 10 to 25 percent pumice sand throughout.

The A horizon has hue of 10YR, value of 5 when dry and 2 or 3 when moist, and chroma of 2 or 3 when moist or dry. It is 0 to 10 percent gravel. The horizon is neutral or mildly alkaline.

The Bw horizon has hue of 10YR, value of 5 or 6 when dry and 3 when moist, and chroma of 3 or 4 when dry and 4 when moist. It is sandy loam or coarse sandy loam and is 0 to 15 percent gravel.

The 2Bk horizon, where present, has hue of 10YR, value of 5 or 6 when dry and 3 when moist, and chroma of 3 or 4 when dry and 4 when moist. It is 15 to 35 percent gravel. Secondary carbonate accumulation occurs as coatings on rock fragments and as free carbonates in matrix.

Choptie Series

The Choptie series consists of shallow, well drained soils on lava plains and hills. These soils formed in colluvium and residuum derived from welded tuff and basalt with ash in the upper part. Slopes are 5 to 20 percent. The mean annual precipitation is about 13 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Choptie loam in an area of Choptie-Westbutte complex, 5 to 20 percent slopes; 300 feet west and 300 feet south of the northeast corner of sec. 24, T. 21 S., R. 20 E.

A—0 to 5 inches; grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; weak thin platy structure parting to weak fine granular; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; many fine vesicular pores; 5 percent gravel; neutral (pH 6.8); clear wavy boundary.

AB—5 to 15 inches; brown (10YR 5/3) loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine and medium roots; common very fine and fine tubular pores; 5 percent gravel and 5 percent cobbles; neutral (pH 6.8); clear wavy boundary.

Bw—15 to 19 inches; brown (10YR 5/3) gravelly loam, very dark grayish brown (10YR 3/2) moist; weak fine and medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common fine and medium roots; common very fine and fine tubular pores; 30

percent gravel; neutral (pH 7.0); abrupt wavy boundary.

R—19 inches; welded tuff.

Depth to bedrock is 10 to 20 inches. The profile is slightly acid or neutral.

The A and AB horizons have value of 2 or 3 when moist and 4 or 5 when dry, and they have chroma of 2 or 3 when moist or dry.

The Bw horizon has value of 3 or 4 when moist and 5 or 6 when dry, and it has chroma of 2 or 3 when moist or dry. It is sandy loam, loam, or gravelly loam and is 12 to 18 percent clay.

Circle Series

The Circle series consists of well drained soils that are deep to glacial outwash. These soils are on outwash plains. They formed in ash over glacial outwash. Slopes are 0 to 30 percent. The mean annual precipitation is about 30 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Circle sandy loam in an area of Allingham-Circle complex, 0 to 15 percent slopes; 1.2 miles on Forest Service Road 200 from Forest Service Road 1230; in the NW1/4SE1/4 of sec. 29, T. 12 S., R. 9 E.

Oi—1 inch to 0; litter of ponderosa pine needles and antelope bitterbrush leaves and twigs.

A1—0 to 3 inches; dark brown (10YR 3/3) sandy loam, dark yellowish brown (10YR 4/4) dry; moderate fine granular structure; slightly hard, friable, nonsticky and nonplastic; many very fine roots and few fine roots; many very fine interstitial pores; 2 percent rounded gravel; neutral (pH 7.2); gradual wavy boundary.

A2—3 to 16 inches; dark brown (10YR 3/3) sandy loam, dark yellowish brown (10YR 4/4) dry; weak fine granular structure; slightly hard, friable, nonsticky and nonplastic; common very fine roots and few fine, medium, and coarse roots; many very fine interstitial pores; 2 percent rounded gravel; neutral (pH 7.2); gradual wavy boundary.

2Bwb1—16 to 28 inches; dark brown (7.5YR 3/4) loam, dark yellowish brown (10YR 4/4) dry; weak fine and medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few very fine, fine, medium, and coarse roots; common very fine interstitial and vesicular pores and few fine tubular pores; 5 percent rounded gravel; neutral (pH 7.0); clear irregular boundary.

2Bwb2—28 to 42 inches; dark yellowish brown (10YR 3/4) gravelly loam, brown (10YR 4/3) dry; moderate medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few fine, medium, and coarse roots; common fine vesicular pores and common medium tubular pores; 25 percent rounded gravel; neutral (pH 7.0); gradual wavy boundary.

3Btb3—42 to 65 inches; dark yellowish brown (10YR 3/4) very gravelly clay loam, brown (10YR 4/3) dry; moderate medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few fine, medium, and coarse roots; common fine vesicular pores and common medium tubular pores; few faint clay films on peds; 40 percent rounded gravel and 10 percent rounded cobbles that are 8 to 13 centimeters in diameter; neutral (pH 7.0).

Depth to the buried glacial outwash material (3Btb horizon) is 40 to 50 inches. Depth to bedrock is more than 60 inches. The profile is slightly acid or neutral.

The O horizon is 1 to 3 inches thick except in areas that have been disturbed.

The A horizon has hue of 10YR when moist or dry, value of 2 or 3 when moist and 4 or 5 when dry, and chroma of 2 or 3 when moist and 2 to 4 when dry. The horizon is 5 to 15 percent clay. It is 0 to 10 percent rounded gravel.

The 2Bwb horizon is 15 to 27 percent clay and 0 to 25 percent rounded gravel.

The 3Btb horizon is 27 to 35 percent clay. It is 30 to 50 percent rounded gravel and 5 to 15 percent rounded cobbles. Total rock fragment content is 35 to 60 percent.

Clinefalls Series

The Clinefalls series consists of very deep, well drained soils on stream terraces. These soils formed in ash over alluvium. Slopes are 0 to 3 percent. The mean annual precipitation is about 11 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Clinefalls sandy loam, 0 to 3 percent slopes; 1,600 feet south and 150 feet east of the northwest corner of sec. 26, T. 14 S., R. 12 E.

A1—0 to 5 inches; dark grayish brown (10YR 4/2) sandy loam, very dark brown (10YR 2/2) moist; weak very fine granular structure; slightly hard, friable, nonsticky and nonplastic; many very fine and fine roots; many very fine irregular pores; 5 percent gravel; neutral (pH 6.8); clear smooth boundary.

A2—5 to 15 inches; grayish brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) moist; weak fine and medium subangular blocky structure parting to granular; slightly hard, friable, nonsticky and nonplastic; common very fine and fine roots; many very fine irregular pores; 10 percent gravel; neutral (pH 6.8); clear wavy boundary.

Bw—15 to 20 inches; grayish brown (10YR 5/2) gravelly sandy loam, very dark grayish brown (10YR 3/2) moist; weak fine and medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; common very fine and fine roots and few medium roots; common very fine and fine irregular pores; 15 percent gravel; neutral (pH 7.0); clear wavy boundary.

BC—20 to 25 inches; brown (10YR 5/3) very gravelly loamy sand, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; soft, friable, nonsticky and nonplastic; common very fine and fine roots and few medium roots; common very fine and fine irregular pores; 35 percent gravel; neutral (pH 7.2); gradual wavy boundary.

2C1—25 to 41 inches; dark gray (10YR 4/1) and white (10YR 8/2) extremely gravelly sand, black (10YR 2/1) and very pale brown (10YR 7/3) moist; single grain; loose, nonsticky and nonplastic; common very fine and fine roots; many very fine irregular pores; 65 percent gravel; mildly alkaline (pH 7.4); abrupt smooth boundary.

3C2—41 to 50 inches; dark gray (10YR 4/1) sand, black (10YR 2/1) moist; single grain; loose, nonsticky and nonplastic; many fine irregular pores; 5 percent gravel; mildly alkaline (pH 7.4); abrupt smooth boundary.

4C3—50 to 60 inches; white (10YR 8/2) extremely gravelly sand, pale brown (10YR 7/3) moist; single grain; loose, nonsticky and nonplastic; many fine irregular pores; 70 percent gravel; mildly alkaline (pH 7.6).

Depth to bedrock is more than 60 inches. Depth to stratified sand and gravel is 20 to 40 inches.

The A horizon has value of 4 or 5 when dry and 2 or 3 when moist, and it has chroma of 1 or 2 when moist or dry. It is 5 to 15 percent gravel.

The Bw and BC horizons have value of 4 or 5 when dry and 2 or 3 when moist, and they have chroma of 2 or 3 when moist or dry. These horizons are 15 to 45 percent gravel.

The C horizon has value of 4 to 8 when dry and 2 to 7 when moist, and it has chroma of 1 to 3 when moist or dry. The horizon is 5 to 70 percent gravel and 0 to 20 percent cobbles. It is stratified sand and gravel with some cobbles. The horizon is neutral or mildly alkaline.

Clovkamp Series

The Clovkamp series consists of deep and very deep, somewhat excessively drained soils on old stream terraces on lava plains. These soils formed in ash over gravelly alluvium. Slopes are 0 to 25 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Clovkamp loamy sand, 0 to 3 percent slopes; 1,300 feet south and 1,200 feet east of the northwest corner of the NW$^1/_4$ of sec. 8, T. 18 S., R. 14 E.

A1—0 to 4 inches; grayish brown (10YR 5/2) loamy sand, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; soft, friable, nonsticky and nonplastic; many very fine roots; many very fine irregular pores; 10 percent gravel; 50 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.0); abrupt smooth boundary.

A2—4 to 12 inches; brown (10YR 5/3) loamy sand, dark brown (10YR 3/3) moist; weak fine subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; common very fine roots; many very fine irregular pores; 10 percent gravel; 40 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.0); clear smooth boundary.

C—12 to 24 inches; brown (10YR 5/3) loamy sand, brown (10YR 4/3) moist; massive; slightly hard, friable, nonsticky and nonplastic; common very fine roots; common very fine irregular pores; 10 percent gravel; 40 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.2); gradual wavy boundary.

2Bqb—24 to 40 inches; pale brown (10YR 6/3) gravelly loamy fine sand, dark grayish brown (10YR 4/2) moist; massive; hard, firm and brittle, nonsticky and nonplastic; few very fine roots; few very fine irregular pores; 20 percent gravel; mildly alkaline (pH 7.6); abrupt wavy boundary.

2Bkqb—40 to 50 inches; pale brown (10YR 6/3) extremely gravelly sand, dark grayish brown (10YR 4/2) moist; massive; very hard, very firm and brittle, nonsticky and nonplastic; few very fine roots; few very fine irregular pores; 65 percent gravel; thin slightly effervescent cap of carbonates at a depth of 40 inches and coatings of carbonates on underside of gravel; mildly alkaline (pH 7.6); abrupt wavy boundary.

2Bkb—50 to 60 inches; pale brown (10YR 6/3) extremely gravelly sand, dark grayish brown (10YR 4/2) moist; single grain; loose, nonsticky and nonplastic; many fine interstitial pores; 80 percent gravel; slightly effervescent; mildly alkaline (pH 7.8).

Depth to bedrock is 40 to 60 inches or more. Depth to the brittle layer is 20 to 40 inches. Depth to carbonates and to the extremely gravelly layer is 35 to 50 inches.

The A horizon has value of 4 or 5 when dry, and it has chroma of 2 or 3 when moist or dry. It is 40 to 70 percent pumice (0.5 to 2.0 millimeters).

The C horizon has value of 5 or 6 when dry and 4 when moist, and it has chroma of 2 or 3 when moist or dry. It is 20 to 50 percent pumice (0.5 to 2.0 millimeters). The horizon is 0 to 10 percent basalt gravel and 0 to 10 percent cobbles. Total rock fragment content is 0 to 15 percent. The horizon is neutral or mildly alkaline.

The 2Bqb horizon has value of 5 or 6 when dry and 4 when moist, and it has chroma of 2 or 3 when moist or dry. It is hard and brittle throughout. It is gravelly loamy fine sand or loamy sand and is 15 to 25 percent gravel.

The 2Bkqb horizon has value of 5 or 6 when dry and 4 when moist, and it has chroma of 2 or 3 when moist or dry. It is extremely gravelly sand or loamy sand and is 65 to 85 percent gravel. It is very hard and brittle throughout. Carbonates occur as a thin layer or as coatings on the underside of gravel.

The 2Bkb horizon, where present, has value of 5 or 6 when dry and 4 when moist, and it has chroma of 2 or 3 when moist or dry. It is extremely gravelly sand or loamy sand and is 65 to 90 percent gravel. Coatings of carbonates are on the underside of gravel.

Cryaquolls

Cryaquolls consist of very deep, very poorly drained and poorly drained soils on pumice-mantled flood plains. These soils formed in mixed alluvium. Slopes are 0 to 3 percent. The mean annual precipitation is 20 inches, and the mean annual air temperature is 43 degrees F.

Representative pedon of Cryaquolls, 0 to 3 percent slopes, in the NW$^1/_4$NE$^1/_4$ of sec. 3, T. 21 S., R. 10 E.

Oi—1 inch to 0; litter from tussock grasses and willow.

A—0 to 2 inches; dark brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; moderate very fine granular structure; soft, very friable, slightly sticky and nonplastic; many very fine, fine, and medium roots; many very fine vesicular pores; moderately acid (pH 6.0); abrupt smooth boundary.

2Ab1—2 to 14 inches; very dark gray (10YR 3/1) loam, gray (10YR 5/1) dry; common fine distinct mottles that are reddish brown (5YR 4/4) when moist; moderate very fine granular structure; soft, very friable, nonsticky and slightly plastic; many very fine, fine, and medium roots; many very fine vesicular pores; neutral (pH 6.6); abrupt smooth boundary.

2Ab2—14 to 18 inches; very dark gray (10YR 3/1) sandy loam, gray (10YR 5/1) dry; common fine distinct mottles that are reddish brown (5YR 4/4) when moist; weak very fine granular structure; soft, very friable, nonsticky and nonplastic; many very fine, fine, and medium roots; many very fine vesicular pores; neutral (pH 6.6); abrupt smooth boundary.

2AC—18 to 22 inches; very dark gray (10YR 3/1) loamy sand, gray (10YR 5/1) dry; single grain; loose, nonsticky and nonplastic; few very fine and fine roots; many very fine vesicular pores; neutral (pH 6.6); abrupt smooth boundary.

3C—22 to 60 inches; very dark gray (10YR 3/1) sand, gray (10YR 5/1) dry; single grain; loose, nonsticky and nonplastic; few very fine and fine roots; many very fine vesicular pores; slightly acid (pH 6.4).

The water table is at the surface to a depth of 24 inches from November to August. Depth to bedrock is more than 60 inches. Layers of diatomaceous earth are in the profile in some areas. The mollic epipedon is 15 to 30 inches thick.

The O horizon is 1 to 3 inches thick except in areas that have been disturbed.

The A horizon has value of 4 or 5 when moist and 6 or 7 when dry.

The 2Ab horizon has value of 2 or 3 when moist and 4 or 5 when dry. The horizon is sandy loam, loam, silt loam, or loamy sand.

Color of the 3C horizon is variable. The horizon is sand, loamy sand, or sandy loam. It is slightly acid or neutral.

Cullius Series

The Cullius series consists of shallow, well drained soils on lava plains and hills. These soils formed in loess over colluvium underlain by volcaniclastic sediment of the Deschutes Formation. Slopes are 0 to 15 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Cullius loam, 3 to 8 percent slopes; 500 feet north and 500 feet west of the southeast corner of the SW$^1/_4$ of sec. 17, T. 12 S., R. 13 E.

Ap—0 to 3 inches; grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; moderate fine granular structure; slightly hard, very friable, nonsticky and nonplastic; many very fine and fine roots; many very fine interstitial pores; neutral (pH 7.2); abrupt smooth boundary.

A—3 to 6 inches; grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; weak medium subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; few very fine roots; many very fine interstitial pores; neutral (pH 7.3); clear wavy boundary.

2Bt1—6 to 9 inches; grayish brown (10YR 5/2) clay loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky structure; slightly hard, firm, nonsticky and slightly plastic; few fine roots; many very fine tubular pores; few faint clay films in pores and on faces of peds; 30 percent clay; 10 percent gravel; mildly alkaline (pH 7.4); clear wavy boundary.

2Bt2—9 to 17 inches; grayish brown (10YR 5/2) clay, dark yellowish brown (10YR 3/4) moist; moderate coarse prismatic structure; hard, firm, sticky and plastic; few very fine tubular pores; many prominent clay films in pores and on faces of peds; 60 percent clay; 10 percent cobbles; mildly alkaline (pH 7.8); abrupt smooth boundary.

2Crkq—17 to 18 inches; weathered, fractured tuff; common medium discontinuous veins of silica and calcium carbonate; effervescent; clear wavy boundary.

2R—18 inches; welded tuff of the Deschutes Formation.

Thickness of the solum and depth to bedrock are 10 to 20 inches.

The A horizon has hue of 10YR, value of 5 when dry and 2 or 3 when moist, and chroma of 2 or 3 when moist or dry.

The 2Bt horizon has hue of 10YR, value of 5 when dry and 3 when moist, and chroma of 2 or 3 when dry and 3 or 4 when moist. It is 0 to 10 percent gravel and 0 to 10 percent cobbles. Total rock fragment content is 0 to 10 percent. The lower part of the horizon has medium or coarse prismatic structure.

The 2Crkq horizon has discontinuous silica cementation and secondary carbonates that occur as soft powdery lime and as coatings on the fractured tuff fragments.

Deschutes Series

The Deschutes series consists of moderately deep, well drained soils on lava plains. These soils formed in ash. Slopes are 0 to 30 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Deschutes sandy loam, 0 to 3 percent slopes; 400 feet west and 200 feet south of the northeast corner of the SE1/4SW1/4 of sec. 26, T. 15 S., R. 12 E.

A1—0 to 3 inches; grayish brown (10YR 5/2) sandy loam, very dark brown (10YR 2/2) moist; moderate very fine granular structure; slightly hard, friable, nonsticky and nonplastic; many very fine roots and common fine and medium roots; many fine interstitial pores; 1 percent subrounded gravel; mildly alkaline (pH 7.6); clear smooth boundary.

A2—3 to 7 inches; dark grayish brown (10YR 4/2) sandy loam, very dark grayish brown (10YR 3/2) moist; weak very fine granular structure; slightly hard, friable, nonsticky and nonplastic; common very fine roots and few fine and medium roots; common fine interstitial pores; 1 percent subrounded gravel; mildly alkaline (pH 7.6); clear smooth boundary.

A3—7 to 17 inches; grayish brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) moist; weak fine and medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few fine, medium, and coarse roots; common fine interstitial pores; 1 percent subrounded gravel; mildly alkaline (pH 7.8); clear smooth boundary.

2Bk—17 to 28 inches; grayish brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) moist; moderate fine, medium, and coarse subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few fine and medium roots; few fine interstitial pores; strongly effervescent; 2 percent subrounded gravel; mildly alkaline (pH 7.8); abrupt wavy boundary.

2Bkq—28 to 31 inches; grayish brown (10YR 5/2) and light grayish brown (10YR 6/2) sandy loam, dark brown (10YR 3/3) moist; strong thin platy structure; hard, firm, nonsticky and nonplastic; few fine roots; many medium and coarse tubular pores; very fine concentrations and pseudomycelia of silica and calcium carbonate; mildly alkaline (pH 7.8); abrupt broken boundary.

3R—31 inches; basalt.

Depth to bedrock is 20 to 40 inches. The particle-size control section is 5 to 10 percent clay and 55 to 75 percent sand.

The A horizon has value of 4 or 5 when dry and 2 or 3 when moist, and it has chroma of 2 or 3 when moist and 2 to 4 when dry. It is 0 to 5 percent gravel, 0 to 10 percent cobbles, and 0 to 5 percent stones. Total rock fragment content is 0 to 10 percent. The horizon is neutral or mildly alkaline.

The 2B horizon has value of 5 or 6 when dry and 3 or 4 when moist, and it has chroma of 2 to 4 when moist or dry. It is 0 to 5 percent gravel, 0 to 10 percent cobbles, and 0 to 5 percent stones. Total rock fragment content is 0 to 20 percent. The horizon is sandy loam or gravelly sandy loam. It is 0 to 15 percent durinodes. Thin coatings of lime are on rock fragments and durinodes.

Deskamp Series

The Deskamp series consists of moderately deep, somewhat excessively drained soils on lava plains. These soils formed in ash. Slopes are 0 to 15 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Deskamp loamy sand in an area of Deskamp-Gosney complex, 0 to 8 percent slopes; 100 feet west and 50 feet south of the northeast corner of sec. 15, T. 18 S., R. 12 E.

A1—0 to 4 inches; brown (10YR 4/3) loamy sand, dark brown (10YR 3/3) moist; single grain; loose, nonsticky and nonplastic; many very fine and fine roots; many very fine and fine interstitial pores; neutral (pH 7.0); clear smooth boundary.

A2—4 to 10 inches; brown (10YR 5/3) loamy sand, dark brown (10YR 3/3) moist; weak fine and medium subangular structure; slightly hard, very friable, nonsticky and nonplastic; common very fine and fine roots; many very fine interstitial pores; neutral (pH 7.0); clear smooth boundary.

AC—10 to 17 inches; brown (10YR 5/3) loamy sand, dark brown (10YR 3/3) moist; weak medium and coarse subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic, common very fine and fine roots; many very fine interstitial pores; neutral (pH 7.2); clear wavy boundary.

2Cq1—17 to 25 inches; pale brown (10YR 6/3) gravelly loamy sand, dark brown (10YR 4/3) moist; weak medium and coarse subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; common very fine and fine roots; many very fine interstitial pores; 5 percent weakly cemented nodules that are hard when dry and friable when moist; 20 percent gravel; mildly alkaline (pH 7.4); clear wavy boundary.

2Cq2—25 to 32 inches; pale brown (10YR 6/3) gravelly loamy sand, dark brown (10YR 4/3) moist; weak medium subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; few very fine and fine roots; few very fine and fine interstitial pores; 10 percent weakly cemented nodules; 25 percent gravel; mildly alkaline (pH 7.4); abrupt wavy boundary.

3R—32 inches; basalt.

Depth to bedrock is 20 to 40 inches.

The A and AC horizons have value of 4 or 5 when dry and 2 or 3 when moist, and they have chroma of 2 or 3 when dry and 1 to 3 when moist. The horizons are loamy sand or sandy loam and are 0 to 5 percent gravel.

The 2C horizon is loamy sand or gravelly loamy sand. It is 10 to 25 percent gravel and 0 to 10 percent cobbles. Total rock fragment content is 10 to 30 percent. The horizon is 0 to 10 percent weakly cemented silica nodules that are friable when moist. It is neutral or mildly alkaline.

Dester Series

The Dester series consists of moderately deep, well drained soils on lava plains. These soils formed in ash over old alluvium. Slopes are 0 to 8 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Dester sandy loam, 0 to 8 percent slopes; in the SE$^1/_4$NW$^1/_4$ of sec. 1, T. 20 S., R. 17 E.

A1—0 to 4 inches; grayish brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) moist; weak medium platy structure; slightly hard, friable, slightly sticky and nonplastic; common very fine and fine roots; many fine and medium irregular pores; neutral (pH 7.0); clear wavy boundary.

A2—4 to 17 inches; grayish brown (10YR 5/2) sandy loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and nonplastic; common very fine and fine roots; many fine and medium irregular pores; neutral (pH 7.0); clear smooth boundary.

2Bt1—17 to 24 inches; brown (10YR 5/3) clay loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky structure; hard, firm, sticky and plastic; few fine roots; common very fine tubular pores; few faint clay films on peds and in pores; neutral (pH 7.3); clear wavy boundary.

2Bt2—24 to 34 inches; light yellowish brown (10YR 6/4) gravelly clay loam, dark yellowish brown (10YR 4/4) moist; moderate medium subangular blocky structure; hard, very firm, very sticky and very plastic; few fine roots; few very fine tubular pores; 15 percent gravel; effervescent in spots; moderately alkaline (pH 7.9); abrupt wavy boundary.

3R—34 inches; basalt; thin, discontinuous coating of opal on bedrock.

Depth to bedrock is 20 to 40 inches.

The A horizon has chroma of 2 or 3 when dry. The horizon is sandy loam or gravelly loamy sand and is 0 to 20 percent gravel and 5 to 15 percent clay.

The 2Bt horizon has chroma of 2 to 4 when moist or dry. The horizon is gravelly clay loam, sandy clay loam, or clay loam. It is 27 to 35 percent clay and 0 to 25 percent gravel.

Douthit Series

The Douthit series consists of very deep, well drained soils on moraines. These soils formed in ash over glacial till. Slopes are 0 to 50 percent. The mean annual precipitation is about 60 inches, and the mean annual air temperature is about 40 degrees F.

Typical pedon of Douthit sandy loam, 15 to 30 percent slopes, 1,000 feet north and 200 feet east of the southwest corner of sec. 1, T. 12 S., R. 8 E.

Oi—2 inches to 0; litter of white fir leaves and twigs.

A1—0 to 3 inches; very dark grayish brown (10YR 3/2) sandy loam, brown (10YR 4/3) dry; weak fine granular structure; slightly hard, friable, nonsticky and nonplastic; many very fine roots and common fine and medium roots; many very fine irregular pores; 10 percent gravel, 2 percent cobbles, and 2 percent stones; neutral (pH 6.8); gradual wavy boundary.

A2—3 to 12 inches; dark yellowish brown (10YR 3/4) cobbly sandy loam, dark yellowish brown (10YR 4/4) dry; weak fine subangular blocky structure parting to single grain; slightly hard, friable, nonsticky and nonplastic; many very fine roots and common fine, medium, and coarse roots; many very fine irregular pores; 15 percent gravel, 10 percent cobbles, and 5 percent stones; neutral (pH 7.0); gradual irregular boundary.

2C1—12 to 52 inches; dark brown (7.5YR 3/4) extremely stony sandy loam, brown (7.5YR 4/4) dry; single grain; slightly hard, friable, nonsticky and nonplastic; many very fine roots and common fine, medium, and coarse roots; many very fine irregular pores; 25 percent gravel, 20 percent cobbles, and 20 percent stones; neutral (pH 7.0); clear irregular boundary.

2C2—52 to 62 inches; dark yellowish brown (10YR 3/4) extremely stony sandy loam, pale brown (10YR 6/3) dry; single grain; slightly hard, friable, nonsticky and nonplastic; many very fine roots and common fine, medium, and coarse roots; many fine irregular pores; 25 percent gravel, 20 percent cobbles, and 20 percent stones; neutral (pH 7.0).

Depth to bedrock is more than 60 inches. Depth to glacial till is 10 to 20 inches. The profile is 5 to 15 percent clay throughout.

The O horizon is 1 to 3 inches thick except in areas that have been disturbed.

The A horizon has hue of 10YR or 7.5YR, and it has value of 3 when moist and 4 or 5 when dry. The A1 horizon has chroma of 2 or 3 when moist or dry, and the A2 horizon has chroma of 3 or 4 when moist or dry. The A horizon is 10 to 20 percent gravel, 0 to 15 percent cobbles, and 0 to 10 percent stones. Total rock fragment content is 10 to 35 percent.

The 2C horizon has hue of 10YR or 7.5YR, value of 2 or 3 when moist and 4 to 6 when dry, and chroma of 3 or 4 when moist or dry. It is sandy loam or loamy sand and is 20 to 30 percent gravel, 15 to 25 percent cobbles, and 10 to 20 percent stones. Total rock fragment content is 40 to 70 percent.

Embal Series

The Embal series consists of very deep, well drained soils on flood plains and alluvial fans. These soils formed in recent alluvium that is high in content of volcanic ash. Slopes are 0 to 3 percent. The mean annual precipitation is about 11 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Embal sandy loam, 0 to 3 percent slopes; $^{3}/_{8}$ mile north of Misery Flat Well; about 150 feet north and 15 feet east of the southwest corner of sec. 2, T. 22 S., R. 22 E.

A1—0 to 2 inches; grayish brown (10YR 5/3) sandy loam, very dark grayish brown (10YR 3/2) moist; weak medium platy structure parting to weak fine granular; slightly hard, friable, slightly sticky and slightly plastic; common very fine roots; many fine vesicular pores; 2 percent gravel; neutral (pH 7.0); abrupt smooth boundary.

A2—2 to 10 inches; grayish brown (10YR 5/2) sandy loam, dark brown (10YR 3/3) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine and fine roots; common very fine tubular pores; 2 percent gravel; mildly alkaline (pH 7.4); clear smooth boundary.

A3—10 to 20 inches; brown (10YR 5/3) sandy loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; hard, firm, slightly sticky and slightly plastic; common fine and medium roots; few very fine tubular pores; 2 percent gravel; mildly alkaline; (pH 7.6); clear wavy boundary.

C1—20 to 30 inches; brown (10YR 5/3) sandy loam, dark brown (10YR 3/3) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few fine and medium roots; few very fine tubular pores; 10 percent gravel; mildly alkaline (pH 7.6); gradual smooth boundary.

C2—30 to 60 inches; grayish brown (10YR 5/3) gravelly sandy loam, very dark grayish brown (10YR 3/2) moist; single grain; soft, very friable, nonsticky and nonplastic; few fine and medium roots; common fine irregular pores; 25 percent gravel; mildly alkaline (pH 7.6).

Depth to bedrock is more than 60 inches. The profile is 30 to 50 percent sand-sized pumice ash. The mollic epipedon is 20 to 35 inches thick. The profile is 10 to 18 percent clay throughout.

The A horizon has value of 4 or 5 when dry and 2 or 3 when moist, and it has chroma of 2 or 3 when moist or dry. The horizon is neutral or mildly alkaline.

The C horizon has value of 5 or 6 when dry and 3 or 4 when moist, and it has chroma of 2 or 3 when moist or dry. The horizon is sandy loam, loam, or gravelly sandy loam and is 0 to 35 percent gravel. It is mildly alkaline or moderately alkaline.

Era Series

The Era series consists of very deep, well drained soils in swales and on hills. These soils formed in ash over old alluvium. Slopes are 0 to 8 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is 48 degrees F.

Typical pedon of Era sandy loam, cobbly substratum, 0 to 3 percent slopes; 2 miles east of Madras, on Ashwood Road; east of north-south fence line; 50 feet south and 10 feet east of the northwest corner of sec. 8, T. 11 S., R. 14 E.

Ap—0 to 3 inches; brown (10YR 5/3) sandy loam, very dark grayish brown (10YR 3/2) moist; weak very fine granular structure; slightly hard, very friable, nonsticky and nonplastic; few very fine and fine roots; many very fine interstitial pores; mildly alkaline (pH 7.6); abrupt smooth boundary.

A—3 to 10 inches; brown (10YR 5/3) sandy loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; few very fine roots; many very fine tubular pores; mildly alkaline (pH 7.8); clear smooth boundary.

Bw—10 to 28 inches; pale brown (10YR 6/3) sandy loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few very fine roots; common very fine tubular pores; moderately alkaline (pH 8.0); gradual wavy boundary.

Bk1—28 to 36 inches; pale brown (10YR 6/3) sandy loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few very fine and fine roots; many very fine interstitial pores; slightly effervescent; moderately alkaline (pH 8.4); abrupt wavy boundary.

Bk2—36 to 42 inches; pale brown (10YR 6/3) sandy loam, dark brown (10YR 3/3) moist; massive; slightly hard, friable, nonsticky and nonplastic; many very fine tubular pores; slightly effervescent; strongly alkaline (pH 8.8); clear wavy boundary.

2Bk3—42 to 60 inches; brown (10YR 5/3) very cobbly sandy loam, dark brown (10YR 3/3) moist; massive; very hard, firm, nonsticky and nonplastic; many very fine interstitial pores; 20 percent gravel and 30 percent cobbles; carbonates in seams and as coatings on rock fragments; strongly effervescent; strongly alkaline (pH 8.8).

Depth to bedrock is more than 60 inches. Depth to secondary carbonates is 30 to 44 inches.

The A horizon has hue of 10YR, value of 5 when dry and 3 when moist, and chroma of 2 or 3 when moist or dry.

The Bw and Bk horizons have hue of 10YR, value of 5 or 6 when dry and 3 when moist, and chroma of 3 or 4 when moist or dry. They are moderately alkaline or strongly alkaline.

The 2Bk horizon has hue of 10YR, value of 5 or 6 when dry and 3 when moist, and chroma of 3 or 4. It is sandy loam, cobbly sandy loam, or very cobbly sandy loam. The horizon is 0 to 25 percent gravel and 0 to 35 percent cobbles. Total rock fragment content is 0 to 40 percent.

The Era soils in this survey area are a taxadjunct to the Era series because the soils are Vitritorrandic. The content of volcanic glass is more than 30 percent throughout, but phosphate retention is less than 25 percent and acid-oxalate aluminum plus one-half the iron is less than 0.4.

Ermabell Series

The Ermabell series consists of very deep, well drained soils on stream terraces. These soils formed in ash over glacial outwash. Slopes are 0 to 3 percent. The mean annual precipitation is about 15 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Ermabell loamy fine sand, 0 to 3 percent slopes; 0.5 mile south of Sisters, on Three Creeks Road; 100 feet east and 100 feet north of the southwest corner of the northwest corner of sec. 9, T. 15 S., R. 10 E.

A1—0 to 8 inches; very dark brown (10YR 2/2) loamy fine sand, dark grayish brown (10YR 4/2) dry; weak fine granular structure; loose, nonsticky and nonplastic; common very fine and fine roots and few medium and coarse roots; many very fine irregular pores; neutral (pH 7.2); clear smooth boundary.

A2—8 to 17 inches; very dark brown (10YR 2/2) loamy fine sand, grayish brown (10YR 5/2) dry; single grain; loose, nonsticky and nonplastic; few very fine, fine, medium, and coarse roots; common very fine irregular pores; neutral (pH 7.2); clear smooth boundary.

A3—17 to 31 inches; very dark brown (10YR 2/2) loamy fine sand, grayish brown (10YR 5/2) dry; single grain; loose, nonsticky and nonplastic; few medium and coarse roots; common very fine irregular pores; 10 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.2); gradual smooth boundary.

AC—31 to 41 inches; very dark brown (10YR 2/2) fine sand, grayish brown (10YR 5/2) dry; single grain; loose, nonsticky and nonplastic; few fine irregular pores; 15 percent pumice (0.5 to 2.0 millimeters); 5 percent gravel; mildly alkaline (pH 7.6); abrupt wavy boundary.

2C—41 to 60 inches; very dark brown (10YR 2/2) very gravelly sand, grayish brown (10YR 5/2) dry; single grain; loose, nonsticky and nonplastic; 30 percent rounded gravel, 15 percent rounded cobbles, and 5 percent rounded boulders; neutral (pH 7.2).

Depth to bedrock is more than 60 inches. Depth to the glacial outwash material (2C horizon) is 40 inches or more. The profile is neutral or mildly alkaline throughout.

The A and AC horizons have hue of 10YR, value of 2 or 3 when moist or dry, and chroma of 2 when moist and 4 or 5 when dry. They are 0 to 5 percent gravel and 5 to 15 percent pumice (0.5 to 2.0 millimeters). The horizons are loamy fine sand, loamy very fine sand, or fine sand and are 2 to 10 percent clay.

The 2C horizon has hue of 10YR, value of 2 or 3 when moist and 4 or 5 when dry, and chroma of 2 or 3 when moist or dry. It is very gravelly sand or extremely gravelly sand. The horizon is 35 to 60 percent gravel, 5 to 15 percent cobbles, and 0 to 5 percent stones. Total rock fragment content is 45 to 80 percent. The horizon is 1 to 5 percent clay.

Flarm Series

The Flarm series consists of very deep, somewhat poorly drained soils in depressions and swales on mountains. These soils formed in ash over colluvium. Slopes are 0 to 15 percent. The mean annual precipitation is about 20 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Flarm loam in an area of Flarm-Smiling complex, 0 to 15 percent slopes; 0.2 mile west of the junction of Forest Service Roads 1180 and 1100; 1,000 feet east and 500 feet north of the southwest corner of sec. 2, T. 12 S., R. 10 E.

Oi—4 inches to 0; litter of ponderosa pine needles and twigs.

A—0 to 4 inches; very dark grayish brown (10YR 3/2) loam, grayish brown (10YR 5/2) dry; moderate very thin platy structure; slightly hard, very friable, slightly sticky and slightly plastic; many very fine, medium, and coarse roots; many very fine interstitial pores; 5 percent rounded gravel; 20 percent clay; neutral (pH 6.8); clear wavy boundary.

2Btb1—4 to 17 inches; dark brown (10YR 4/3) clay loam, pale brown (10YR 6/3) dry; moderate medium subangular blocky structure; hard, very firm, sticky and plastic; few medium and coarse roots; common fine and medium tubular pores; many prominent clay films in pores and on faces of peds; 5 percent rounded gravel; 40 percent clay; neutral (pH 7.0); clear wavy boundary.

2Btb2—17 to 30 inches; dark yellowish brown (10YR 4/4) gravelly clay loam, light yellowish brown (10YR 6/4) dry; common fine distinct dark brown (7.5YR 4/4) mottles; moderate very coarse subangular blocky structure; very hard, very firm, sticky and plastic; few coarse roots; common medium tubular pores; many prominent clay films in pores and on faces of peds; 15 percent rounded gravel; 40 percent clay; neutral (pH 7.0); gradual irregular boundary.

2Btb3—30 to 42 inches; dark yellowish brown (10YR 4/4) gravelly clay loam, pale brown (10YR 6/3) dry; common fine distinct dark brown (7.5YR 4/4) mottles; massive; very hard, very firm, sticky and plastic; few coarse roots; few fine tubular pores; many prominent clay films in pores; 15 percent rounded gravel; 40 percent clay; neutral (pH 7.0); gradual irregular boundary.

3C1—42 to 56 inches; dark yellowish brown (10YR 4/4) sandy loam, pale brown (10YR 6/3) dry; common fine distinct dark brown (7.5YR 4/4) mottles; massive; hard, firm, slightly sticky and slightly plastic; few fine tubular pores; 55 percent saprolitic gravel-sized fragments and 25 percent saprolitic cobble-sized fragments; neutral (pH 7.0); gradual irregular boundary.

3C2—56 to 65 inches; yellowish brown (10YR 5/4) loam, light yellowish brown (10YR 6/4) dry; massive; hard, firm, sticky and slightly plastic; few medium tubular pores; 55 percent saprolitic gravel-sized fragments and 25 percent saprolitic cobble-sized fragments; neutral (pH 7.2).

Depth to bedrock is more than 60 inches. Depth to mottles is 15 to 30 inches.

The O horizon is 3 to 4 inches thick except in areas that have been disturbed.

The A horizon has value of 3 when moist and 4 or 5 when dry, and it has chroma of 2 or 3 when moist or dry. It is 15 to 25 percent clay and 0 to 10 percent rounded gravel.

The 2Btb horizon has chroma of 3 or 4 when moist or dry. It is clay loam, clay, or gravelly clay loam and is 35 to 50 percent clay. The horizon is 5 to 25 percent rounded gravel and 0 to 10 percent rounded and subrounded cobbles. Total rock fragment content is 5 to 35 percent.

The 3C horizon has hue of 7.5YR or 10YR, value of 4 or 5 when moist and 6 when dry, and chroma of 3 or 4 when moist or dry. It is sandy loam or loam and is 10 to 20 percent clay. The horizon is 50 to 80 percent weathered tuff or basalt fragments.

Fluvents

Fluvents consist of very deep, somewhat excessively drained or excessively drained soils on flood plains. These soils formed in recent alluvium. Slopes are 0 to 1 percent. The mean annual precipitation is about 9 inches, and the mean annual air temperature is about 48 degrees F.

Representative pedon of Fluvents, 0 to 1 percent slopes; on a flood plain below the old railroad grade; 1,200 feet east and 700 feet south of the northwest corner of the NW1/4NE1/4 of sec. 30, T. 9 S., R. 13 E.

A—0 to 4 inches; very dark grayish brown (10YR 3/2) loamy sand, grayish brown (10YR 5/2) dry; single grain; loose, nonsticky and nonplastic; many very fine and fine roots, many very fine interstitial pores; neutral (pH 7.0); clear smooth boundary.

C1—4 to 26 inches; very dark grayish brown (10YR 3/2) sand, light brownish gray (10YR 6/2) dry; single grain; loose, nonsticky and nonplastic; common very fine roots; many very fine interstitial pores; neutral (pH 7.0); abrupt smooth boundary.

2C2—26 to 35 inches; dark grayish brown (10YR 4/2) very fine sand, light brownish gray (10YR 6/2) dry; single grain; loose, nonsticky and nonplastic; many very fine interstitial pores; neutral (pH 7.2); abrupt smooth boundary.

3C3—35 to 60 inches; dark brown (10YR 4/3) coarse sand, pale brown (10YR 6/3) dry; single grain; loose, nonsticky and nonplastic; many fine interstitial pores; moderately alkaline (pH 7.4).

Depth to bedrock is more than 60 inches. The coarse fragment content is 0 to 10 percent. Organic matter content decreases irregularly as depth increases.

The A horizon has value of 2 or 3 when moist and 4 or 5 when dry, and it has chroma of 2 or 3 when moist or dry.

The C horizon has value of 3 or 4 when moist, and it has chroma of 2 or 3 when moist or dry. It is stratified sand, very fine sand, and coarse sand with thin layers of loamy material.

Fremkle Series

The Fremkle series consists of shallow, well drained soils on hills. These soils formed in ash. Slopes are 0 to 30 percent. The mean annual precipitation is about 15 inches, and the mean annual air temperature is about 45 degrees F.

Typical pedon of Fremkle sandy loam in an area of Wanoga-Fremkle-Rock outcrop complex, 0 to 15 percent slopes; 200 feet east and 300 feet south of the northwest corner of sec. 8, T. 14 S., R. 11 E.

Oi—1 inch to 0; litter of ponderosa pine and western juniper needles and twigs.

A1—0 to 3 inches; dark brown (10YR 3/3) sandy loam, brown (10YR 5/3) dry; weak fine granular structure; slightly hard, friable, nonsticky and nonplastic; many very fine roots; many very fine irregular pores; 10 percent gravel; neutral (pH 7.2); gradual wavy boundary.

A2—3 to 14 inches; dark brown (10YR 3/3) sandy loam, brown (10YR 4/3) dry; moderate medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; common fine and medium roots; many fine and medium vesicular pores; 10 percent gravel; neutral (pH 7.2); abrupt smooth boundary.

2R—14 inches; fractured tuff.

Depth to bedrock is 10 to 20 inches.

The A horizon has hue of 10YR, value of 3 when moist and 4 or 5 when dry, and chroma of 2 or 3 when moist and 3 when dry. It is 5 to 15 percent gravel.

Fryrear Series

The Fryrear series consists of moderately deep, well drained soils on hills. These soils formed in ash. Slopes are 0 to 50 percent. The mean annual precipitation is about 15 inches, and the mean annual air temperature is about 45 degrees F.

Typical pedon of Fryrear stony sandy loam in an area of Henkle-Lava flows-Fryrear complex, 15 to 50 percent slopes; 100 feet south of the Fremont Canyon Road; in the northwest corner of the SW1/4 of sec. 24, T. 14 S., R. 10 E.

Oi—0.5 inch to 0; ponderosa pine litter.

A1—0 to 3 inches; dark brown (10YR 3/3) stony sandy loam, dark brown (10YR 3/3) dry; weak fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine and fine roots; many very fine interstitial pores; 5 percent gravel, 5 percent cobbles, and 20 percent stones; neutral (pH 7.0); gradual wavy boundary.

A2—3 to 18 inches; dark brown (10YR 3/3) very stony sandy loam, dark brown (10YR 3/3) dry; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine roots and few fine, medium, and coarse roots; many very fine interstitial pores; 5 percent gravel, 10 percent cobbles, and 40 percent stones; neutral (pH 7.0); gradual irregular boundary.

Bw—18 to 27 inches; dark yellowish brown (10YR 3/4) very stony sandy loam, dark yellowish brown (10YR 4/4) dry; moderate fine and medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine roots and few fine, medium, and coarse roots; common very fine interstitial pores and few fine tubular pores; 5 percent gravel, 10 percent cobbles, and 40 percent stones; neutral (pH 7.0); abrupt irregular boundary.

2R—27 inches; fractured basalt; common distinct clay films on fracture faces; 1- to 2-millimeter-thick weathering rind on basalt fragments.

Depth to bedrock is 20 to 40 inches.

The A horizon has hue of 10YR, value of 3 when moist and 3 or 4 when dry, and chroma of 2 or 3 when moist or dry. It is 5 to 10 percent gravel, 5 to 10 percent cobbles, and 15 to 40 percent stones. Total rock fragment content is 25 to 60 percent.

The Bw horizon has hue of 10YR, value of 3 when moist and 4 when dry, and chroma of 4 when moist or dry. It is 5 to 10 percent gravel, 10 to 30 percent cobbles, and 20 to 40 percent stones. Total rock fragment content is 35 to 60 percent. The horizon is very stony sandy loam or very cobbly sandy loam.

Gap Series

The Gap series consists of deep, well drained soils on mountains. These soils formed in ash over colluvium and residuum. Slopes are 0 to 30 percent. The mean annual precipitation is about 30 inches, and the mean annual air temperature is about 42 degrees F.

Typical pedon of Gap sandy loam, 0 to 15 percent slopes; on Forest Service Road 1150-750, 0.1 mile from junction with Forest Service Road 1150; in the SW1/4SW1/4 of sec. 18, T. 12 S., R. 10 E.

Oi—4 inches to 0; litter of ponderosa pine needles and twigs.

A1—0 to 4 inches; dark brown (10YR 4/3) sandy loam, yellowish brown (10YR 5/4) dry; weak fine granular structure; slightly hard, friable, nonsticky and nonplastic; many very fine and fine roots; many very fine interstitial pores; 5 percent gravel; 18 percent clay; neutral (pH 6.8); clear smooth boundary.

A2—4 to 14 inches; reddish brown (5YR 4/4) sandy loam, brown (7.5YR 5/4) dry; weak medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; common fine, medium, and coarse roots; common fine tubular pores; 5 percent gravel; 18 percent clay; neutral (pH 7.0); clear smooth boundary.

2Btb1—14 to 18 inches; reddish brown (5YR 4/4) loam, brown (7.5YR 5/4) dry; moderate medium subangular blocky structure; slightly hard, firm, slightly sticky and slightly plastic; few medium and coarse roots; many very fine tubular pores; few faint clay films in pores; 5 percent gravel and 10 percent soft rock fragments; 22 percent clay; neutral (pH 7.0); clear wavy boundary.

2Btb2—18 to 34 inches; reddish brown (5YR 4/4) clay loam, brown (7.5YR 5/4) dry; strong medium subangular blocky structure; hard, firm, sticky and plastic; few coarse roots; common fine tubular pores; many distinct clay films in pores and on faces of peds; 10 percent gravel and 20 percent soft rock fragments; 28 percent clay; neutral (pH 7.0); clear wavy boundary.

2Btb3—34 to 47 inches; dark brown (7.5YR 4/4) clay loam, strong brown (7.5YR 5/6) dry; strong medium subangular blocky structure; very hard, very firm, sticky and plastic; few coarse roots; common fine tubular pores; many distinct clay films in pores and on faces of peds; 10 percent gravel and 20 percent soft rock fragments; 30 percent clay; neutral (pH 7.0); clear irregular boundary.

2Cr—47 inches; weathered tuff.

Depth to the paralithic contact is 40 to 60 inches. Depth to the buried argillic horizon is 14 to 20 inches.

The O horizon is 2 to 4 inches thick except in areas that have been disturbed.

The A horizon has hue of 5YR, 7.5YR, or 10YR, value of 3 or 4 when moist and 5 when dry, and chroma of 3 or 4 when moist and 4 to 6 when dry. The horizon is 10 to 18 percent clay and 0 to 10 percent gravel.

The 2Btb horizon has hue of 5YR or 7.5YR, value of

4 when moist and 4 to 6 when dry, and chroma of 3 or 4 when moist and 3 to 6 when dry. The horizon is loam or clay loam and is 18 to 35 percent clay. It is 5 to 10 percent gravel and 10 to 25 percent soft rock fragments.

Gardone Series

The Gardone series consists of very deep, excessively drained soils on lava plains. These soils formed in ash. Slopes are 0 to 20 percent. The mean annual precipitation is about 11 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Gardone sand in an area of Stookmoor-Gardone-Rock outcrop, 1 to 15 percent slopes; 200 feet east and 100 feet south of the northwest corner of sec. 14, T. 20 S., R. 1 E.

A—0 to 10 inches; dark grayish brown (10YR 4/2) sand, very dark brown (10YR 2/2) moist; weak thin platy structure; soft, very friable, nonsticky and nonplastic; many very fine roots; many medium irregular pores; 5 percent gravel; neutral (pH 6.8); clear wavy boundary.

AC—10 to 21 inches; grayish brown (10YR 5/2) loamy sand, very dark grayish brown (10YR 3/2) moist; single grain; soft, very friable, nonsticky and nonplastic; common very fine roots; many fine and medium irregular pores; 10 percent gravel; neutral (pH 7.0); clear wavy boundary.

C1—21 to 34 inches; pale brown (10YR 6/3) loamy sand, very dark grayish brown (10YR 3/2) moist; single grain; soft, very friable, nonsticky and nonplastic; few very fine roots; many fine and medium irregular pores; 5 percent gravel; neutral (pH 7.0); clear wavy boundary.

C2—34 to 60 inches; light brownish gray (10YR 6/2) loamy sand, very dark grayish brown (10YR 3/2) moist; single grain; soft, very friable, nonsticky and nonplastic; few very fine roots; many fine and medium irregular pores; 5 percent gravel; neutral (pH 7.0).

Depth to bedrock is more than 60 inches. Depth to a buried loamy layer is 40 to 60 inches or more.

The A horizon has value of 4 or 5 when dry and 2 or 3 when moist. It is 0 to 15 percent gravel.

The AC horizon has chroma of 2 or 3 when moist or dry. It is 0 to 25 percent gravel. It is neutral or mildly alkaline.

The C horizon has value of 4 to 7 when dry and 3 to 7 when moist, and it has chroma of 2 or 3 when moist or dry. The horizon is loamy sand, sand, or gravelly loamy sand. It is 0 to 25 percent gravel. It is neutral or mildly alkaline.

Glaze Series

The Glaze series consists of deep, well drained soils on mountains. These soils formed in ash over colluvium and residuum. Slopes are 15 to 50 percent. The mean annual precipitation is about 30 inches, and the mean annual air temperature is about 42 degrees F.

Typical pedon of Glaze sandy loam in an area of Glaze-Prairie-Rock outcrop complex, 30 to 50 percent slopes; in roadcut above road on south side of draw on Forest Service Road 1150, 0.2 mile from junction with Forest Service Road 1140-820; in the NE$^1/_4$SE$^1/_4$ of sec. 7, T. 12 S., R. 10 E.

Oi—3 inches to 0; litter of ponderosa pine needles and twigs.

A1—0 to 4 inches; dark yellowish brown (10YR 3/4) sandy loam, dark yellowish brown (10YR 4/4) dry; single grain; slightly hard, friable, nonsticky and nonplastic; many very fine and fine roots; few fine interstitial pores; 5 percent gravel and 5 percent cobbles; 10 percent clay; neutral (pH 6.8); clear smooth boundary.

A2—4 to 19 inches; dark brown (7.5YR 4/4) cobbly sandy loam, brown (7.5YR 5/4) dry; weak medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; common fine and medium roots; many very fine and fine interstitial pores; 15 percent gravel and 15 percent cobbles; 15 percent clay; neutral (pH 7.0); gradual wavy boundary.

2Btb1—19 to 33 inches; dark brown (7.5YR 4/4) very cobbly loam, brown (7.5YR 5/4) dry; moderate medium subangular blocky structure; slightly hard, firm, slightly sticky and slightly plastic; common medium roots; many very fine tubular pores; few faint clay films on faces of peds; 30 percent gravel, 20 percent cobbles, and 5 percent stones; 20 percent clay; neutral (pH 7.2); gradual wavy boundary.

2Btb2—33 to 54 inches; dark brown (7.5YR 4/4) extremely stony loam, brown (7.5YR 5/4) dry; moderate medium subangular blocky structure; slightly hard, firm, slightly sticky and slightly plastic; common coarse roots; few fine tubular pores; common faint clay films in pores and on faces of peds; 30 percent gravel, 25 percent cobbles, and 30 percent stones; 20 percent clay; neutral (pH 7.2); clear irregular boundary.

2Cr—54 inches; weathered tuff.

Depth to the paralithic contact is 40 to 60 inches. Depth to the buried argillic horizon is 14 to 20 inches.

The O horizon is 2 to 4 inches thick except in areas that have been disturbed.

The A horizon has value of 3 or 4 when moist and 4 or 5 when dry, and it has chroma of 3 or 4 when moist or dry. The horizon is sandy loam or cobbly sandy loam and is 10 to 18 percent clay. It is 0 to 15 percent gravel and 0 to 15 percent cobbles. Total rock fragment content is 0 to 30 percent.

The 2Btb horizon has hue of 7.5YR, value of 4 or 5 when moist or dry, and chroma of 4 when moist or dry. It is very cobbly loam, extremely stony loam, or very cobbly clay loam and is 18 to 35 percent clay. The horizon is 15 to 30 percent gravel, 15 to 40 percent cobbles, and 10 to 30 percent stones. Total rock fragment content is 35 to 70 percent.

Gosney Series

The Gosney series consists of shallow, somewhat excessively drained soils on lava plains. These soils formed in ash. Slopes are 0 to 15 percent. The mean annual precipitation is about 11 inches, and the mean annual air temperature is about 49 degrees F.

Typical pedon of Gosney stony loamy sand in an area of Gosney-Rock outcrop-Deskamp complex, 0 to 15 percent slopes; at the northwest corner of the intersection of U.S. Highway 20 and Gosney Road; in the NW1/4NE1/4 of sec. 5, T. 18 S., R. 13 E.

A1—0 to 2 inches; grayish brown (10YR 5/2) stony loamy sand, very dark grayish brown (10YR 3/2) moist; single grain; loose, nonsticky and nonplastic; many very fine roots; many very fine irregular pores; 5 percent gravel, 5 percent cobbles, and 10 percent stones; neutral (pH 6.8); abrupt smooth boundary.

A2—2 to 4 inches; grayish brown (10YR 5/2) loamy sand, very dark grayish brown (10YR 3/2) moist; weak very fine granular structure; soft, very friable, nonsticky and nonplastic; many very fine roots; many very fine irregular pores; 5 percent gravel; neutral (pH 7.2); clear smooth boundary.

AC—4 to 8 inches; grayish brown (10YR 5/2) loamy sand, dark brown (10YR 3/3) moist; single grain; slightly hard, friable, nonsticky and nonplastic; common very fine roots; many very fine irregular pores; 5 percent gravel; neutral (pH 7.2); clear wavy boundary.

C—8 to 14 inches; pale brown (10YR 6/3) loamy sand, dark brown (10YR 3/3) moist; single grain; slightly hard, friable, nonsticky and nonplastic; common very fine roots; common very fine irregular pores; 5 percent gravel and 5 percent cobbles; mildly alkaline (pH 7.4); abrupt irregular boundary.

2R—14 inches; basalt.

Depth to bedrock is 10 to 20 inches. The content of pumice (0.5 to 2.0 millimeters) is 20 to 60 percent.

The A horizon has value of 4 or 5 when dry and 2 or 3 when moist, and it has chroma of 2 or 3 when dry and 1 to 3 when moist. The horizon is 5 to 15 percent gravel, 0 to 10 percent cobbles, and 5 to 20 percent stones. Total rock fragment content is 5 to 45 percent. The horizon is 0.5 to 1.0 percent organic matter.

The C horizon has value of 5 or 6 when dry and 3 or 4 when moist. It is loamy sand or gravelly loamy sand. It is 5 to 25 percent gravel and 0 to 10 percent cobbles. Total rock fragment content is 10 to 30 percent. The horizon is neutral or mildly alkaline.

Haynap Series

The Haynap series consists of very deep, somewhat excessively drained soils on moraines. These soils formed in ash and scoria. Slopes are 0 to 70 percent. The mean annual precipitation is about 60 inches, and the mean annual air temperature is about 40 degrees F.

Typical pedon of Haynap very gravelly loamy coarse sand, 0 to 15 percent slopes; in roadcut 0.2 mile from Forest Service Road 1210; in the SW1/4NE1/4 of sec. 24, T. 13 S., R. 8 E.

Oi—2 inches to 0; litter of Douglas fir and white fir needles and twigs.

A1—0 to 3 inches; black (10YR 2/1) very gravelly loamy coarse sand, grayish brown (10YR 5/2) dry; single grain; loose, nonsticky and nonplastic; many very fine roots and few fine roots; many very fine and fine irregular pores; 40 percent gravel; neutral (pH 7.0); clear wavy boundary.

A2—3 to 15 inches; dark brown (10YR 3/3) very gravelly loamy coarse sand, brown (10YR 4/3) dry; single grain; loose, nonsticky and nonplastic; many very fine and fine roots, common medium roots, and few coarse roots; many very fine and fine irregular pores; 40 percent gravel; neutral (pH 7.0); clear wavy boundary.

2C1—15 to 18 inches; black (10YR 2/1) extremely gravelly loamy coarse sand, gray (10YR 5/1) dry; single grain; loose, nonsticky and nonplastic; few very fine roots; many fine and medium irregular pores; 70 percent gravel; neutral (pH 7.0); abrupt smooth boundary.

2C2—18 to 20 inches; black (10YR 2/1) and dark yellowish brown (10YR 3/6) extremely gravelly loamy coarse sand, gray (10YR 5/1) and yellowish brown (10YR 5/6) dry; single grain; loose, nonsticky and nonplastic; few very fine roots; many fine and medium irregular pores; 70 percent gravel; neutral (pH 7.0); abrupt smooth boundary.

2C3—20 to 29 inches; black (10YR 2/1) extremely gravelly loamy coarse sand, gray (10YR 5/1) dry;

single grain; loose, nonsticky and nonplastic; few very fine roots; many fine and medium irregular pores; 80 percent gravel; neutral (pH 7.0); abrupt smooth boundary.

3C4—29 to 41 inches; very dark gray (10YR 3/1) loamy fine sand, very dark grayish brown (10YR 3/2) dry; single grain; loose, nonsticky and nonplastic; common fine and medium roots; many very fine irregular pores; 2 percent gravel; neutral (pH 7.2); clear irregular boundary.

3C5—41 to 49 inches; black (10YR 2/1) loamy fine sand, very dark gray (10YR 3/1) dry; single grain; loose, nonsticky and nonplastic; common fine and medium roots; many very fine irregular pores; 2 percent gravel; neutral (pH 7.2); clear irregular boundary.

4C6—49 to 62 inches; dark brown (10YR 3/3) sandy loam, brown (10YR 5/3) dry; single grain; loose, nonsticky and nonplastic; common fine and medium roots and few coarse roots; many very fine irregular pores; 2 percent gravel; neutral (pH 7.2).

Depth to bedrock is more than 60 inches. Rock fragments in the profile are gravel-sized cinders.

The O horizon is 1 to 3 inches thick except in areas that have been disturbed.

The A horizon has hue of 10YR, value of 2 or 3 when moist and 4 or 5 when dry, and chroma of 1 to 3 when moist and 2 or 3 when dry. The horizon is 35 to 50 percent gravel. It is slightly acid or neutral.

The 2C horizon has hue of 10YR, value of 2 or 3 when moist and 5 when dry, and chroma of 1 to 6 when moist or dry. The horizon is 60 to 90 percent scoriaceous gravel.

The 3C and 4C horizons have hue of 10YR, value of 2 or 3 when moist and 3 to 5 when dry, and chroma of 1 to 3 when moist or dry. They are loamy fine sand and sandy loam and are 2 to 10 percent gravel.

Haystack Series

The Haystack series consists of very deep, well drained soils on alluvial fans. These soils formed in colluvium. Slopes are 0 to 8 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Haystack loam in an area of Era-Haystack complex, 0 to 8 percent slopes; 200 feet west and 300 feet north of the southeast corner of the NW¼ of sec. 26, T. 13 S., R. 13 E.

A1—0 to 3 inches; dark grayish brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; weak thin platy structure; slightly hard, friable, nonsticky and nonplastic; many very fine roots; many very fine interstitial pores; 10 percent gravel; neutral (pH 7.0); clear smooth boundary.

A2—3 to 6 inches; dark grayish brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; weak fine subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; many very fine roots; many very fine interstitial pores; 10 percent gravel; neutral (pH 7.0); clear smooth boundary.

AB—6 to 11 inches; brown (10YR 5/3) loam, dark brown (10YR 3/3) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine roots; many very fine and fine interstitial pores and many fine vesicular pores; 10 percent gravel; neutral (pH 7.2); clear smooth boundary.

Bt1—11 to 17 inches; brown (10YR 5/3) very gravelly loam, dark brown (10YR 4/3) moist; weak fine subangular blocky structure; slightly hard, firm, slightly sticky and slightly plastic; common very fine roots and few fine roots; many very fine and fine interstitial pores and many fine vesicular pores; 40 percent gravel; few faint clay films in pores and on faces of peds; neutral (pH 7.2); clear wavy boundary.

Bt2—17 to 26 inches; brown (10YR 5/3) extremely gravelly loam, dark brown (10YR 4/3) moist; weak fine subangular blocky structure; slightly hard, firm, slightly sticky and slightly plastic; common very fine roots and few fine roots; many fine interstitial pores; 50 percent gravel and 20 percent cobbles; few faint clay films in pores and on faces of peds; mildly alkaline (pH 7.4); clear smooth boundary.

C—26 to 40 inches; brown (10YR 5/3) extremely gravelly loamy sand, dark brown (10YR 3/3) moist; massive; loose, nonsticky and nonplastic; many very fine interstitial pores; 60 percent gravel and 20 percent cobbles; mildly alkaline (pH 7.4); gradual wavy boundary.

Ck—40 to 60 inches; brown (10YR 5/3) extremely gravelly loamy sand, dark brown (10YR 3/3) moist; massive; loose, nonsticky and nonplastic; many very fine interstitial pores; 60 percent gravel and 20 percent cobbles; 5 percent secondary lime nodules and coatings on gravel; strongly effervescent; moderately alkaline (pH 8.0).

Depth to bedrock is more than 60 inches. Depth to secondary lime is 30 to 44 inches.

The A horizon has value of 2 or 3 when moist and 4 or 5 when dry, and it has chroma of 2 or 3 when moist or dry. The horizon is 15 to 25 percent clay and is 0 to 15 percent gravel.

The Bt horizon has value of 3 or 4 when moist, and it has chroma of 3 or 4 when moist or dry. It is very gravelly loam, extremely gravelly loam, or very gravelly clay loam. The horizon is 20 to 30 percent clay. It is 35 to 55 percent gravel and 0 to 20 percent cobbles. Total rock fragment content is 35 to 70 percent. The horizon is neutral or mildly alkaline.

The C and Ck horizons are 40 to 60 percent gravel and 10 to 30 percent cobbles. Total rock fragment content is 60 to 80 percent. The C horizon is loamy sand or sandy loam and is 5 to 15 percent clay. The Ck horizon is loamy sand and is 5 to 10 percent clay. The horizons are mildly alkaline or moderately alkaline throughout. Secondary lime occurs as seams and nodules or as coatings on coarse fragments.

Henkle Series

The Henkle series consists of shallow, somewhat excessively drained soils on hills. These soils formed in ash. Slopes are 0 to 50 percent. The mean annual precipitation is about 15 inches, and the mean annual air temperature is about 45 degrees F.

Typical pedon of Henkle very cobbly sandy loam in an area of Henkle-Fryrear-Lava flows complex, 0 to 15 percent slopes; on the northeast slope of Henkle Butte; in the NW$^1/_4$SE$^1/_4$ of sec. 24, T. 14 S., R. 10 E.

Oi—0.5 inch to 0; litter of ponderosa pine and western juniper needles and twigs.

A1—0 to 2 inches; very dark brown (10YR 2/2) very cobbly sandy loam, brown (10YR 4/3) dry; weak fine granular structure; slightly hard, friable, nonsticky and nonplastic; many very fine roots; many very fine irregular pores; 15 percent gravel, 20 percent cobbles, and 10 percent stones; neutral (pH 7.0); gradual wavy boundary.

A2—2 to 17 inches; dark brown (10YR 3/3) very cobbly sandy loam, brown (10YR 4/3) dry; weak fine subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; common very fine, fine, and medium roots; many very fine irregular pores; 15 percent gravel, 20 percent cobbles, and 10 percent stones; neutral (pH 7.0); abrupt irregular boundary.

2R—17 inches; fractured basalt; common distinct clay films on fracture faces; 1- to 2-millimeter-thick weathering rind on basalt fragments.

Depth to bedrock is 10 to 20 inches.

The A horizon has hue of 10YR, value of 2 or 3 when moist and 4 when dry, and chroma of 2 or 3 when moist and 3 when dry. It is 10 to 20 percent gravel, 15 to 25 percent cobbles, and 5 to 15 percent stones. Total rock fragment content is 35 to 50 percent.

Holmzie Series

The Holmzie series consists of moderately deep, well drained soils on hills. These soils formed in ash over residuum. Slopes are 0 to 30 percent. The mean annual precipitation is about 11 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Holmzie loam in an area of Holmzie-Searles complex, 0 to 15 percent slopes; 300 feet east of Holmes Road on jeep trail; in the SW$^1/_4$NW$^1/_4$ of sec. 23, T. 14 S., R. 11 E.

A—0 to 7 inches; dark grayish brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; slightly hard, friable, nonsticky and slightly plastic; many very fine and fine roots and common medium roots; many very fine irregular pores; 10 percent pumice (0.5 to 2.0 millimeters); 2 percent gravel and 10 percent cobbles; 23 percent clay; neutral (pH 7.2); clear wavy boundary.

2Btb—7 to 19 inches; brown (10YR 5/3) clay loam, dark brown (10YR 3/3) moist; strong fine and medium subangular blocky structure; hard, firm, slightly sticky and plastic; few fine and coarse roots and common medium roots; few fine vesicular pores, few medium tubular pores, and common fine irregular pores; 10 percent pumice (0.5 to 2.0 millimeters); 2 percent gravel and 10 percent cobbles; common distinct clay films on peds and in pores; 33 percent clay; neutral (pH 7.2); clear wavy boundary.

3Btb—19 to 29 inches; reddish brown (5YR 4/3) gravelly clay, reddish brown (5YR 4/3) moist; strong fine and medium subangular blocky structure; hard, very firm, slightly sticky and plastic; few fine roots; few fine vesicular pores, few medium tubular pores, and common fine irregular pores; 20 percent gravel and 10 percent cobbles; many prominent clay films on peds and in pores; 45 percent clay; mildly alkaline (pH 7.6); clear wavy boundary.

3Cr—29 inches; weathered tuff.

Depth to the paralithic contact is 20 to 40 inches.

The A horizon has hue of 10YR, value of 3 when moist and 4 or 5 when dry, and chroma of 2 or 3 when moist and 2 when dry. It is 0 to 10 percent gravel and 0 to 10 percent cobbles. Total rock fragment content is 5 to 15 percent.

The 2Btb horizon has hue of 10YR, value of 3 when moist and 3 or 4 when dry, and chroma of 3 when moist or dry. It is clay loam or gravelly clay loam and is 30 to 40 percent clay. The horizon is 0 to 15 percent gravel and 0 to 10 percent cobbles. Total rock fragment content is 5 to 20 percent.

The 3Btb horizon has hue of 7.5YR or 5YR, value of 4 when moist or dry, and chroma of 3 when moist or dry. It is gravelly clay or cobbly clay and is 40 to 50 percent clay. The horizon is 10 to 30 percent gravel and 5 to 15 percent cobbles. Total rock fragment content is 15 to 35 percent.

Houstake Series

The Houstake series consists of very deep, well drained soils on lava plains. These soils formed in ash. Slopes are 0 to 8 percent. The mean annual precipitation is about 11 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Houstake sandy loam in an area of Deschutes-Houstake complex, 0 to 8 percent slopes; 100 feet east and 200 feet south of the northwest corner of sec. 34, T. 15 S., R. 13 E.

A—0 to 5 inches; brown (10YR 5/3) sandy loam, very dark grayish brown (10YR 3/2) moist; moderate very fine granular structure; slightly hard, very friable, nonsticky and nonplastic; many very fine roots; many very fine interstitial pores; 10 percent clay; neutral (pH 7.3); clear smooth boundary.

AB—5 to 17 inches; brown (10YR 5/3) sandy loam, dark brown (10YR 3/3) moist; weak medium and fine subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; common very fine, fine, and medium roots; common very fine tubular and interstitial pores; 10 percent clay; mildly alkaline (pH 7.4); abrupt wavy boundary.

Bw—17 to 22 inches; brown (10YR 5/3) sandy loam, dark brown (10YR 3/3) moist; moderate fine, medium, and coarse angular blocky structure; slightly hard, firm, nonsticky and nonplastic; common very fine and fine roots; common fine and medium tubular pores; 15 percent clay; slightly effervescent; mildly alkaline (pH 7.6); clear wavy boundary.

2Bq1—22 to 30 inches; light brownish gray (10YR 6/2) sandy loam, dark grayish brown (10YR 4/2) moist; moderate fine, medium, and coarse angular blocky structure; hard, very firm and brittle, nonsticky and nonplastic; common very fine and fine roots; few medium and coarse tubular pores; 15 percent clay; slightly effervescent; moderately alkaline (pH 8.2); abrupt wavy boundary.

2Bq2—30 to 60 inches; brown (10YR 5/3) sandy loam, dark brown (10YR 3/3) moist; moderate fine, medium, and coarse angular blocky structure; hard, very firm and brittle, nonsticky and nonplastic; common very fine and fine roots; many very fine interstitial and tubular pores; 10 percent clay; slightly effervescent; moderately alkaline (pH 8.2).

Depth to bedrock is more than 60 inches. Depth to the brittle layer is 20 to 40 inches.

The A horizon has chroma of 2 or 3.

The Bw horizon is sandy loam or loamy sand. It is neutral or mildly alkaline.

The 2Bq horizon has value of 5 or 6 when dry and 3 or 4 when moist, and it has chroma of 2 or 3 when moist or dry. The horizon is sandy loam or fine sandy loam. It is very gravelly below a depth of 40 inches in some pedons. It is mildly alkaline or moderately alkaline.

Iris Series

The Iris series consists of very deep, well drained soils in lake basins on lava plains. These soils formed in alluvium and loess. Slopes are 0 to 1 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Iris silt loam, 0 to 1 percent slopes; 1.2 miles west of Culver; 700 feet south and 100 feet east of the northwest corner of the SE$^1/_4$ of sec. 24, T. 12 S., R. 12 E.

Ap—0 to 4 inches; brown (10YR 5/3) silt loam, very dark grayish brown (10YR 3/2) moist; massive; slightly hard, very friable, slightly sticky and slightly plastic; few very fine roots; many very fine interstitial pores; neutral (pH 7.2); clear smooth boundary.

A—4 to 14 inches; brown (10YR 5/3) silt loam, very dark grayish brown (10YR 3/2) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few fine roots; many very fine interstitial pores; neutral (pH 7.2); clear smooth boundary.

Bw—14 to 34 inches; pale brown (10YR 6/3) silt loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; slightly hard, very friable, sticky and slightly plastic; few very fine roots; many very fine tubular pores; mildly alkaline (pH 7.6); clear wavy boundary.

Bkq—34 to 60 inches; pale brown (10YR 6/3) silt loam, brown (10YR 4/3) moist; massive; hard, firm and brittle, slightly sticky and nonplastic; many very fine tubular pores; slightly effervescent; mildly alkaline (pH 7.6).

Depth to bedrock is 60 inches or more. Depth to carbonates and to the brittle layer is 20 to 40 inches.

The A horizon hue of 10YR, value of 5 when dry and 3 when moist, and chroma of 2 or 3 when moist or dry.

The Bw horizon has hue of 10YR, value of 6 when dry and 3 when moist, and chroma of 2 or 3 when moist or dry. It is neutral or mildly alkaline.

The Bkq horizon has hue of 10YR, value of 6 when dry and 3 or 4 when moist, and chroma of 2 or 3 when moist or dry.

Kweo Series

The Kweo series consists of excessively drained soils that are moderately deep to cinders. These soils are on cinder cones. They formed in ash over cinders. Slopes are 8 to 50 percent. The mean annual precipitation is about 30 inches, and the mean annual air temperature is about 42 degrees F.

Typical pedon of Kweo gravelly sandy loam, 8 to 50 percent slopes; on east slope of cinder cone; in the NW1/4NW1/4 of sec. 22, T. 12 S., R. 9 E.

Oi—1 inch to 0; mat of ponderosa pine and Douglas fir needles and twigs.

A—0 to 13 inches; dark brown (7.5YR 3/4) gravelly sandy loam, brown (7.5YR 5/4) dry; weak fine granular structure; slightly hard, friable, nonsticky and nonplastic; many very fine, fine, and medium roots; many very fine irregular pores; 20 percent angular gravel and 5 percent angular cobbles; neutral (pH 7.2); gradual wavy boundary.

AC—13 to 25 inches; dark reddish brown (5YR 3/4) very gravelly sandy loam, brown (7.5YR 5/4) dry; weak fine subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; common fine roots and few very fine, medium, and coarse roots; common fine irregular and vesicular pores; 40 percent angular gravel and 5 percent angular cobbles; neutral (pH 7.2); clear wavy boundary.

C—25 to 60 inches; dark yellowish brown (10YR 4/6) cinders, yellowish brown (10YR 5/6) dry; single grain; loose, nonsticky and nonplastic; few fine roots; many medium vesicular pores; less than 10 percent of voids filled; neutral (pH 7.2).

Thickness of the solum and depth to cinders are 20 to 35 inches. Depth to bedrock is more than 60 inches.

The A horizon has hue of 7.5YR, value of 2 or 3 when moist and 4 or 5 when dry, and chroma of 4 when moist or dry. It is 15 to 25 percent gravel and 0 to 10 percent cobbles. Total coarse fragment content (cinders) is 15 to 30 percent. Content of clay is 5 to 15 percent.

The AC horizon has hue of 5YR or 7.5YR when moist and 7.5YR when dry, value of 3 or 4 when moist and 5 or 6 when dry, and chroma of 4 when moist or dry. It is gravelly or very gravelly sandy loam. The horizon is 25 to 35 percent gravel and 0 to 10 percent cobbles. Total coarse fragment content (cinders) is 25 to 40 percent. The horizon is 5 to 15 percent clay.

The C horizon has hue of 5YR to 10YR, value of 3 or 4 when moist and 3 to 5 when dry, and chroma of 2 to 6 when moist or dry. It is 90 to 100 percent gravel-sized cinders.

Lafollette Series

The Lafollette series consists of well drained soils that are moderately deep to very gravelly old alluvium. These soils are on stream terraces. They formed in ash over old alluvium. Slopes are 0 to 8 percent. The mean annual precipitation is about 11 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Lafollette sandy loam, 0 to 3 percent slopes; 300 feet east of gravel road off Lower Bridge Road; in the NW1/4NE1/4 of sec. 19, T. 14 S., R. 12 E.

A1—0 to 6 inches; brown (10YR 5/3) sandy loam, very dark brown (10YR 2/2) moist; weak fine granular structure; slightly hard, friable, nonsticky and nonplastic; common very fine roots; common very fine irregular pores; 10 percent clay; neutral (pH 6.8); abrupt smooth boundary.

A2—6 to 24 inches; brown (10YR 5/3) sandy loam, very dark grayish brown (10YR 3/2) moist; weak medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few very fine roots; few very fine irregular pores; 10 percent gravel; 10 percent clay; neutral (pH 6.8); clear wavy boundary.

2AC—24 to 35 inches; pale brown (10YR 6/3) very gravelly sandy loam, dark yellowish brown (10YR 4/4) moist; moderate fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few fine tubular pores; 40 percent rounded gravel; 15 percent clay; neutral (pH 7.0); clear wavy boundary.

2C1—35 to 42 inches; very gravelly sandy loam that has pale brown (10YR 6/3) matrix with multicolored (10YR 6/2, 7/1, and 5/3) sand particles, dark yellowish brown (10YR 4/4) moist; massive; hard, friable, slightly sticky and slightly plastic; 55 percent rounded gravel; 10 percent clay; neutral (pH 7.0); abrupt smooth boundary.

3C2—42 to 60 inches; extremely gravelly loamy coarse sand that has dark gray (10YR 4/1) matrix and multicolored (10YR 6/2, 7/1, and 5/3) sand particles, black (10YR 2/1) moist; 80 percent rounded gravel and 10 percent rounded cobbles; neutral (pH 7.0).

Depth to bedrock is 60 inches or more. Depth to the very gravelly substratum is 20 to 40 inches.

The A horizon has hue of 10YR, value of 2 or 3 when moist and 5 when dry, and chroma of 2 when moist and 3 when dry. It is 0 to 10 percent gravel and 5 to 10 percent clay.

The 2AC horizon has hue of 10YR, value of 4 when moist and 6 when dry, and chroma of 3 when moist and 4 when dry. It is 35 to 60 percent gravel and 5 to 10 percent clay.

The 2C and 3C horizons have hue of 10YR, value of 4 when moist and 6 when dry, and chroma of 3 when moist and 4 when dry. The 2C horizon is 35 to 60 percent gravel and 5 to 10 percent clay, and the 3C horizon is 65 to 80 percent gravel and 0 to 5 percent clay.

A thin layer of welded tuff is between the 2AC and 2C horizons in some pedons.

Laidlaw Series

The Laidlaw series consists of very deep, well drained soils in swales on hills. These soils formed in ash over old alluvium. Slopes are 0 to 15 percent. The mean annual precipitation is about 15 inches, and the mean annual air temperature is about 45 degrees F.

Typical pedon of Laidlaw sandy loam, 0 to 15 percent slopes; 200 feet south and 200 feet east of the northwest corner of sec. 24, T. 14 S., R. 10 E.

Oi—1 inch to 0; litter of ponderosa pine twigs and needles.

A1—0 to 5 inches; dark brown (10YR 3/3) sandy loam, brown (10YR 4/3) dry; weak very fine granular structure; slightly hard, friable, nonsticky and nonplastic; many very fine roots and common fine roots; many very fine interstitial pores; 2 percent gravel; neutral (pH 7.0); clear wavy boundary.

A2—5 to 15 inches; dark brown (10YR 3/3) sandy loam, brown (10YR 4/3) dry; weak medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; common very fine roots; many very fine interstitial pores; 2 percent gravel; neutral (pH 7.0); gradual wavy boundary.

Bw—15 to 26 inches; dark yellowish brown (10YR 3/4) sandy loam, dark yellowish brown (10YR 4/4) dry; weak medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few fine, medium, and coarse roots; many very fine interstitial pores; 2 percent gravel; neutral (pH 7.0); clear wavy boundary.

Bq1—26 to 38 inches; dark brown (10YR 3/3) sandy loam, yellowish brown (10YR 5/4) dry; moderate medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few fine and medium roots; few medium tubular pores and many fine vesicular pores; 10 percent silica nodules that are hard or very hard when dry, are firm when moist, and have iron and manganese stains; 2 percent gravel; neutral (pH 7.2); clear wavy boundary.

2Bq2—38 to 45 inches; dark brown (10YR 3/3) fine sandy loam, brown (10YR 4/3) dry; weak medium subangular blocky structure; loose, nonsticky and nonplastic; few fine, medium, and coarse roots; few medium tubular pores and many fine interstitial pores; 30 percent silica nodules that are hard or very hard when dry and are firm when moist; neutral (pH 7.2); gradual wavy boundary.

2Bq3—45 to 60 inches; dark brown (10YR 3/3) loamy fine sand, dark grayish brown (2.5Y 4/2) dry; weak medium subangular blocky structure; loose, nonsticky and nonplastic; few fine, medium, and coarse roots; few medium tubular pores and many fine interstitial pores; 10 percent silica nodules that are hard or very hard when dry and are firm when moist; neutral (pH 7.2).

Depth to bedrock is more than 60 inches.

The A horizon has hue of 10YR, value of 3 when moist and 4 when dry, and chroma of 3 when moist and 3 or 4 when dry. It is 0 to 5 percent gravel.

The 2Bq horizon has hue of 10YR or 2.5Y, value of 3 when moist and 4 or 5 when dry, and chroma of 3 or 4 when moist or dry. It is fine sandy loam or loamy fine sand. It is 0 to 5 percent gravel and 5 to 30 percent silica nodules.

A 2C horizon, where present, has hue of 10YR, value of 4 or 5 when moist and 6 to 8 when dry, and chroma of 4 to 6 when moist or dry. It is 25 to 35 percent pumiceous gravel and 60 to 80 percent pumice sand (0.5 to 2.0 millimeters). It is hard and brittle.

Lapine Series

The Lapine series consists of very deep, excessively drained soils on pumice-mantled lava plains and hills. These soils formed in pumice and ash. Slopes are 0 to 70 percent. The mean annual precipitation is about 20 inches, and the mean annual air temperature is about 43 degrees F.

Typical pedon of Lapine gravelly loamy coarse sand, low, 0 to 3 percent slopes; 800 feet east and 1,200 feet south of the northwest corner of sec. 7, T. 25 S., R. 9 E.

A1—0 to 3 inches; very dark grayish brown (10YR 3/2) gravelly loamy coarse sand, grayish brown (10YR 5/2) dry; weak fine subangular blocky structure parting to weak fine granular; soft, very friable, nonsticky and nonplastic; many very fine and fine roots and few medium roots; many very fine and fine interstitial pores; 15 percent gravel-sized pumice; slightly acid (pH 6.5); clear smooth boundary.

A2—3 to 7 inches; dark brown (10YR 3/3) gravelly loamy coarse sand, brown (10YR 5/3) dry; weak fine and medium subangular blocky structure; soft, very friable, nonsticky and nonplastic; many very fine and fine roots and few medium roots; many very fine and fine interstitial pores; 20 percent gravel-sized pumice; slightly acid (pH 6.5); clear smooth boundary.

C1—7 to 24 inches; very pale brown (10YR 7/4) extremely gravelly loamy coarse sand, white (2.5Y 8/2) and pale yellow (2.5Y 8/4) dry; single grain; loose, nonsticky and nonplastic; common very fine and fine roots and few medium roots; many very fine and fine interstitial pores; 65 percent gravel-sized pumice; neutral (pH 6.6); clear smooth boundary.

C2—24 to 37 inches; light gray (2.5Y 7/2) and pale yellow (2.5Y 7/4) very gravelly coarse sand, white (2.5Y 8/2) and pale yellow (2.5Y 8/4) dry; single grain; loose, nonsticky and nonplastic; few very fine roots; common very fine and fine interstitial pores; 40 percent gravel-sized pumice; neutral (pH 6.8); clear smooth boundary.

C3—37 to 49 inches; light gray (2.5Y 7/2) and pale yellow (2.5Y 7/4) gravelly coarse sand, white (N 8/0) dry; single grain; loose, nonsticky and nonplastic; few very fine roots; common very fine interstitial pores; 30 percent gravel-sized pumice; neutral (pH 7.0); clear smooth boundary.

C4—49 to 60 inches; light gray (2.5Y 7/2), pale yellow (2.5Y 7/4), and light brownish gray (2.5Y 6/2) gravelly coarse sand, white (N 8/0) dry; single grain; loose, nonsticky and nonplastic; 20 percent gravel-sized pumice; neutral (pH 7.0).

Depth to bedrock is more than 60 inches. Depth to buried loamy material is 40 to 60 inches or more. The particle-size control section averages 35 to 70 percent gravel-sized pumice fragments.

The A horizon has value of 2 or 3 when moist and 4 or 5 when dry, and it has chroma of 2 or 3 when moist or dry. It is 15 to 35 percent gravel-sized pumice fragments.

The C horizon has hue of 10YR to 2.5Y, value of 5 to 7 when moist and 6 to 8 when dry, and chroma of 0 to 4 when moist or dry. It is loamy coarse sand or coarse sand and is 40 to 70 percent gravel-sized pumice fragments. It is slightly acid or neutral.

Lickskillet Series

The Lickskillet series consists of shallow, well drained soils on hills and canyonsides. These soils formed in colluvium. Slopes are 0 to 80 percent. The mean annual precipitation is about 9 inches, and the mean annual air temperature is about 47 degrees F.

Typical pedon of Lickskillet very gravelly loam in an area of Lickskillet-Redcliff very gravelly loams, 30 to 60 percent south slopes; 200 feet south and 300 feet east of the northwest corner of the NE$^1/_4$ of sec. 24, T. 13 S., R. 13 E.

A1—0 to 4 inches; dark grayish brown (10YR 4/2) very gravelly loam, very dark brown (10YR 2/2) moist; weak very fine granular structure; slightly hard, very friable, nonsticky and nonplastic; common very fine and fine roots; many very fine interstitial pores; 45 percent gravel; neutral (pH 7.2); clear wavy boundary.

A2—4 to 9 inches; dark grayish brown (10YR 4/2) very gravelly loam, very dark brown (10YR 2/2) moist; weak very fine subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; many very fine and fine roots; many very fine interstitial pores; 45 percent gravel; neutral (pH 7.2); clear wavy boundary.

Bw—9 to 13 inches; brown (10YR 5/3) extremely gravelly loam, very dark grayish brown (10YR 3/2) moist; weak medium subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; few very fine roots; many very fine interstitial pores; 70 percent gravel; mildly alkaline (pH 7.4); clear smooth boundary.

R—13 inches; fractured rhyolite.

Depth to bedrock is 12 to 20 inches.

The A horizon has value of 2 or 3 when moist, and it has chroma of 2 or 3 when moist or dry. It is very stony sandy loam or very gravelly loam.

The Bw horizon has value of 5 or 6 when dry, and it has chroma of 2 or 3 when moist or dry. It is very gravelly loam, extremely gravelly loam, very cobbly loam, or very cobbly sandy loam. The horizon is 50 to 75 percent rock fragments. It is neutral or mildly alkaline.

Some of the Lickskillet soils in this survey area have a sandy loam subsoil (less than 18 percent clay), which is outside the range of characteristics for the series. These soils are between Bend and Juniper Butte.

Linksterly Series

The Linksterly series consists of very deep, well drained soils on moraines. These soils formed in ash over glacial till. Slopes are 0 to 50 percent. The mean annual precipitation is about 60 inches, and the mean annual air temperature is about 40 degrees F.

Typical pedon of Linksterly sandy loam, 15 to 30 percent slopes; in the NW$^1/_4$NE$^1/_4$ of sec. 21, T. 13 S., R. 8 E.

Oi—3 inches to 0; litter of white fir and Douglas fir needles and twigs.

A1—0 to 4 inches; very dark grayish brown (10YR 3/2) sandy loam, brown (10YR 4/3) dry; weak fine granular structure; slightly hard, friable, nonsticky and nonplastic; many very fine and fine roots; many very fine irregular pores; 2 percent gravel; neutral (pH 7.0); gradual wavy boundary.

A2—4 to 14 inches; very dark grayish brown (10YR 3/2) sandy loam, brown (10YR 5/3) dry; weak fine subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; many very fine roots and common fine and medium roots; many very fine irregular pores; 2 percent gravel; neutral (pH 7.0); gradual wavy boundary.

2C1—14 to 32 inches; black (10YR 2/1) loamy fine sand, dark grayish brown (10YR 4/2) dry; single grain; loose, very friable, nonsticky and nonplastic; few coarse roots and common fine and medium roots; many very fine irregular pores; 2 percent gravel; neutral (pH 7.0); clear wavy boundary.

2C2—32 to 41 inches; very dark grayish brown (10YR 3/2) loamy fine sand, dark yellowish brown (10YR 4/4) dry; weak fine subangular blocky structure; soft, very friable, nonsticky and nonplastic; few fine roots and common medium and coarse roots; many very fine irregular pores and few fine tubular pores; 5 percent gravel; neutral (pH 7.0); clear irregular boundary.

3C3—41 to 60 inches; dark reddish brown (7.5YR 3/4) very cobbly sandy loam, brown (7.5YR 5/4) dry; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and nonplastic; weak fine, medium, and coarse roots; many very fine irregular pores and few fine tubular pores; 20 percent gravel, 20 percent cobbles, and 10 percent stones; neutral (pH 7.0).

Depth to bedrock is more than 60 inches. Depth to glacial till is 40 to 60 inches.

The O horizon is 1 to 4 inches thick except in areas that have been disturbed.

The A horizon has hue of 10YR, value of 3 when moist and 4 or 5 when dry, and chroma of 2 or 3 when moist or dry. It is 5 to 15 percent clay and 2 to 5 percent gravel.

The 2C horizon has hue of 10YR, value of 2 or 3 when moist and 4 when dry, and chroma of 1 or 2 when moist and 2 to 4 when dry. It is 5 to 10 percent clay and 2 to 5 percent gravel.

The 3C horizon has hue of 7.5YR or 10YR, value of 3 or 4 when moist and 5 when dry, and chroma of 4 when moist and 4 or 6 when dry. The horizon is very cobbly sandy loam or very cobbly loam. It is 15 to 25 percent gravel, 15 to 25 percent cobbles, and 5 to 15 percent stones. Total rock fragment content is 35 to 50 percent. The horizon is 10 to 18 percent clay.

Lundgren Series

The Lundgren series consists of well drained soils that are moderately deep to glacial outwash. These soils are on outwash plains. They formed in ash over glacial outwash. Slopes are 0 to 3 percent. The mean annual precipitation is about 15 inches, and the mean annual air temperature is about 45 degrees F.

Typical pedon of Lundgren sandy loam, 0 to 3 percent slopes; 1,800 feet east and 1,000 feet south of the northwest corner of sec. 36, T. 15 S., R. 10 E.

A1—0 to 5 inches; very dark brown (10YR 2/2) sandy loam, grayish brown (10YR 5/2) dry; weak fine granular structure; slightly hard, friable, nonsticky and nonplastic; many very fine and fine roots; many very fine and fine irregular pores; neutral (pH 6.8); clear smooth boundary.

A2—5 to 14 inches; very dark grayish brown (10YR 3/2) sandy loam, brown (10YR 5/3) dry; weak fine and medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; common very fine and fine roots; common very fine and fine irregular pores; 10 percent gravel; neutral (pH 7.0); clear smooth boundary.

Bw—14 to 23 inches; dark brown (10YR 3/3) gravelly sandy loam, yellowish brown (10YR 5/4) dry; moderate fine and medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; common very fine and fine roots; common very fine and fine irregular pores; 20 percent gravel; neutral (pH 7.0); abrupt wavy boundary.

2C1—23 to 38 inches; dark brown (10YR 4/3) very gravelly loam, pale brown (10YR 6/3) dry; massive; slightly hard, friable, nonsticky and nonplastic; few very fine and fine roots; few very fine and fine irregular pores; 45 percent gravel and 5 percent cobbles; neutral (pH 7.2); gradual wavy boundary.

2C2—38 to 60 inches; brown (10YR 4/3) extremely gravelly sandy loam, pale brown (10YR 6/3) dry; massive; slightly hard, friable, nonsticky and nonplastic; few very fine roots; few very fine irregular pores; 50 percent gravel and 15 percent cobbles; neutral (pH 7.2).

Depth to the glacial outwash material (2C horizon) is 20 to 40 inches. Depth to bedrock is more than 60 inches. The solum is 20 to 60 percent pumice sand (0.5 to 2.0 millimeters).

The A horizon has value of 2 or 3 when moist and 4 or 5 when dry, and it has chroma of 2 or 3 when moist or dry. It is 0 to 10 percent gravel.

The Bw horizon has value of 3 or 4 when moist and 5 or 6 when dry, and it has chroma of 3 or 4 when moist or dry. It is 20 to 30 percent gravel.

The 2C horizon has value of 3 or 4 when moist and 5 or 6 when dry, and it has chroma of 3 or 4 when moist or dry. The horizon is very gravelly loam, very gravelly sandy loam, or extremely gravelly sandy loam and is 35 to 60 percent gravel and 5 to 15 percent cobbles. Total rock fragment content is 40 to 65 percent.

Madras Series

The Madras series consists of moderately deep, well drained soils on lava plains and hills. These soils formed in loess over volcaniclastic sediment of the Deschutes Formation. Slopes are 0 to 15 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Madras loam, 0 to 3 percent slopes; 100 feet east and 50 feet south of the northwest corner of the SW$^1/_4$SW$^1/_4$ of sec. 23, T. 10 S., R. 13 E.

Ap1—0 to 4 inches; brown (10YR 5/3) loam, dark brown (10YR 3/3) moist; massive; slightly hard, very friable, nonsticky and nonplastic; few very fine and fine roots; many very fine interstitial pores; neutral (pH 6.8); abrupt smooth boundary.

Ap2—4 to 10 inches; brown (10YR 5/3) loam, dark brown (10YR 3/3) moist; moderate thick platy structure; hard, friable, nonsticky and nonplastic; common very fine roots; many very fine interstitial pores; neutral (pH 6.8); abrupt smooth boundary.

Bt1—10 to 16 inches; yellowish brown (10YR 5/4) loam, dark brown (10YR 4/3) moist; weak coarse subangular blocky structure; hard, friable, nonsticky and nonplastic; many very fine roots; many very fine tubular pores; few faint clay films lining pores and on faces of peds; 25 percent clay; neutral (pH 7.2); clear smooth boundary.

Bt2—16 to 23 inches; yellowish brown (10YR 5/4) clay loam, dark brown (10YR 4/3) moist; weak coarse subangular blocky structure; hard, friable, slightly sticky and slightly plastic; common very fine roots; many very fine tubular pores; common prominent clay films lining pores and on faces of peds; 35 percent clay; mildly alkaline (pH 7.6); clear wavy boundary.

2Crk—23 to 27 inches; consolidated gravel, cobbles, and sand of the Deschutes Formation; moderately effervescent, carbonates along fractures; clear wavy boundary.

2R—27 inches; basalt of the Deschutes Formation.

Depth to bedrock, consisting of basalt or tuff, is 22 to 40 inches. The particle-size control section averages 25 to 35 percent clay.

The A horizon has hue of 10YR, value of 5 when dry and 3 when moist, and chroma of 3 when dry and 2 or 3 when moist. It is sandy loam or loam. It is neutral or mildly alkaline.

The Bt horizon has hue of 10YR, value of 5 when dry and 3 when moist, and chroma of 4 when moist or dry. It is loam, clay loam, cobbly loam, or cobbly clay loam. The horizon is 0 to 20 percent gravel and 0 to 25 percent cobbles. Total rock fragment content is 5 to 30 percent. The horizon is neutral to moderately alkaline.

Menbo Series

The Menbo series consists of moderately deep, well drained soils on hills. These soils formed in colluvium with ash in the upper part. Slopes are 5 to 25 percent. The mean annual precipitation is about 13 inches, and the mean annual air temperature is about 43 degrees F.

Typical pedon of Menbo stony loam, 5 to 25 percent slopes; on a northeast slope of Pine Mountain; in the SW$^1/_4$NW$^1/_4$ of sec. 20, T. 20 S., R. 16 E.

A1—0 to 3 inches; grayish brown (10YR 5/2) stony loam, very dark grayish brown (10YR 3/2) moist; weak thick platy structure; soft, very friable, slightly sticky and slightly plastic; many very fine roots; many fine irregular pores; about 10 percent stones and 10 percent gravel; neutral; clear wavy boundary.

A2—3 to 8 inches; dark grayish brown (10YR 4/2) gravelly loam, very dark brown (10YR 2/2) moist; weak fine subangular blocky structure parting to weak fine granular; slightly hard, very friable, slightly sticky and slightly plastic; many very fine roots; many very fine irregular pores; about 5 percent cobbles and 20 percent gravel; neutral; clear wavy boundary.

2Bt—8 to 26 inches; brown (10YR 5/3) very cobbly clay loam, dark brown (10YR 3/3) moist; moderate medium angular blocky structure; hard, firm, very sticky and plastic; common very fine roots; common very fine tubular pores; common moderately thick clay films on faces of peds and few thin clay films in pores; about 20 percent cobbles and 20 percent gravel; neutral; abrupt irregular boundary.

2R—26 inches; fractured basalt.

Depth to bedrock is 20 to 40 inches. The mollic epipedon is 20 to 35 inches thick.

The A horizon has value of 4 or 5 when dry, and it has chroma of 2 or 3 when moist or dry. The horizon is 5 to 15 percent volcanic ash. It is 0 to 25 percent cobbles and stones and 0 to 30 percent gravel.

The 2Bt horizon has hue of 10YR or 7.5YR, value of 4 or 5 when dry and 3 or 4 when moist, and chroma of 2 to 4. It is 35 to 50 percent clay, 15 to 30 percent cobbles and stones, and 20 to 40 percent gravel. It is very gravelly clay loam or very cobbly clay.

Milcan Series

The Milcan series consists of somewhat excessively drained soils that are moderately deep to a duripan. These soils are in basins on lava plains. They formed in ash over old alluvium. Slopes are 0 to 5 percent. The mean annual precipitation is about 11 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Milcan gravelly sandy loam, 0 to 5 percent slopes; in the NE1/4NE1/4SW1/4 of sec. 34, T. 20 S., R. 16 E.

A1—0 to 8 inches; grayish brown (10YR 5/2) gravelly sandy loam, very dark grayish brown (10YR 3/2) moist; massive; slightly hard, friable, nonsticky and nonplastic; many very fine and fine roots; many fine and medium irregular pores; about 25 percent gravel; about 45 percent ash; neutral (pH 7.3); clear smooth boundary.

A2—8 to 17 inches; brown (10YR 5/3) loamy sand, dark brown (10YR 3/3) moist; massive; soft, very friable, nonsticky and nonplastic; many very fine roots; many fine and medium irregular pores; about 5 percent gravel; 30 percent ash; mildly alkaline (pH 7.5); gradual smooth boundary.

AB—17 to 24 inches; pale brown (10YR 6/3) sandy loam, brown (10YR 3/3) moist; massive; slightly hard, friable, nonsticky and nonplastic; common very fine roots; many fine irregular pores; about 5 percent gravel; about 35 percent ash; mildly alkaline (pH 7.4); clear smooth boundary.

Bq—24 to 38 inches; pale brown (10YR 6/3) sandy loam, dark brown (10YR 3/3) moist; massive; slightly hard, friable, slightly sticky and nonplastic; few very fine roots; many very fine irregular pores; about 10 percent gravel; many durinodes and pockets of firm, brittle material; about 15 percent ash; mildly alkaline (pH 7.4); abrupt wavy boundary.

2Bkqm—38 to 60 inches; pale brown (10YR 6/3) duripan, dark brown (10YR 3/3) moist; platy; indurated; slightly effervescent.

Depth to the indurated duripan is 20 to 40 inches. Depth to bedrock is more than 60 inches.

The upper part of the A horizon has value of 4 or 5 when dry and 3 when moist, and it has chroma of 2 or 3 when moist or dry.

The lower part of A horizon and the AB horizon have value of 5 to 7 when dry and 3 or 4 when moist, and they have chroma of 2 or 3 when moist or dry. They are loamy sand, gravelly sandy loam, or sandy loam and are 0 to 25 percent gravel. They are neutral or mildly alkaline.

The Bq horizon is sandy loam or gravelly sandy loam. It is 0 to 25 percent gravel. It is neutral to moderately alkaline.

Minkwell Series

The Minkwell series consists of very deep, well drained soils on moraines. These soils formed in ash over glacial till. Slopes are 0 to 50 percent. The mean annual precipitation is about 60 inches, and the mean annual air temperature is about 40 degrees F.

Typical pedon of Minkwell sandy loam, 15 to 30 percent slopes; on Forest Service Road 1280-220, 0.5 mile from junction with Forest Service Road 1280-200; in the NE1/4 of sec. 8, T. 12 S., R. 9 E.

Oi—1 inch to 0; litter of Douglas fir, white fir, and ponderosa pine needles and twigs and incense cedar leaves and twigs.

A1—0 to 2 inches; dark brown (7.5YR 3/4) sandy loam, brown (10YR 4/3) dry; moderate fine granular structure; slightly hard, friable, nonsticky and nonplastic; common very fine, fine, and coarse roots and many medium roots; many very fine and fine interstitial pores; 5 percent subangular gravel (2 to 5 millimeters); neutral (pH 7.0); clear smooth boundary.

A2—2 to 10 inches; dark brown (7.5YR 3/4) sandy loam, dark yellowish brown (10YR 4/4) dry; weak fine granular structure; slightly hard, friable, nonsticky and nonplastic; common very fine, fine, and coarse roots and many medium roots; many very fine and fine interstitial pores; 5 percent subangular gravel (2 to 5 millimeters); neutral (pH 7.0); gradual wavy boundary.

Bw—10 to 23 inches; dark brown (7.5YR 3/4) sandy loam, brown (7.5YR 4/4) dry; weak fine subangular blocky structure parting to single grain; slightly hard, friable, nonsticky and nonplastic; common fine and medium roots and few coarse roots; common very fine and fine interstitial pores; 5 percent subangular gravel (2 to 5 millimeters); 5 percent dark brown, weakly cemented nodules; neutral (pH 7.0); clear irregular boundary.

2Bwb—23 to 34 inches; dark reddish brown (5YR 3/4) cobbly loam, brown (7.5YR 4/4) dry; moderate medium and coarse subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; common fine and medium roots and few coarse roots; common fine interstitial and vesicular pores and few fine tubular pores; 5 percent subangular gravel and 15 percent subangular cobbles; neutral (pH 7.2); gradual wavy boundary.

3Btb1—34 to 47 inches; dark reddish brown (5YR 3/4) cobbly clay loam, brown (7.5YR 4/4) dry; moderate medium and coarse subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; common fine and medium roots and few coarse roots; common fine interstitial and vesicular pores and few fine tubular pores; common distinct clay films on peds and in pores; 5 percent subangular gravel and 15 percent subangular cobbles; neutral (pH 7.2); gradual wavy boundary.

3Btb2—47 to 60 inches; dark brown (7.5YR 3/4) cobbly clay loam, brown (7.5YR 4/4) dry; moderate medium and coarse subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; few fine, medium, and coarse roots; common fine interstitial and vesicular pores and few fine tubular pores; many distinct clay films on peds and in pores; 5 percent gravel and 10 percent cobbles; neutral (pH 7.2).

Depth to cobbly glacial till material (2Bwb horizon) is 20 to 30 inches. Depth to the buried argillic horizon (3Btb horizon) is 30 to 40 inches. Depth to bedrock is more than 60 inches.

The O horizon is 1 to 3 inches thick except in areas that have been disturbed.

The A horizon has hue of 7.5YR when moist and 7.5YR or 10YR when dry, value of 2 or 3 when moist and 4 or 5 when dry, and chroma of 4 when moist and 3 or 4 when dry. The horizon is 5 to 15 percent clay. It is 0 to 10 percent subangular gravel and 0 to 5 percent cobbles. Total rock fragment content is 0 to 15 percent.

The 2Bwb horizon has hue of 5YR when moist and 7.5YR when dry, value of 3 when moist and 4 when dry, and chroma of 4 when moist or dry. The horizon is 15 to 27 percent clay. It is 0 to 10 percent subangular gravel, 10 to 20 percent subangular cobbles, and 0 to 5 percent subangular stones. Total rock fragment content is 15 to 35 percent.

The 3Btb horizon has hue of 5YR and 7.5YR when moist or dry, value of 3 when moist and 4 when dry, and chroma of 4 when moist or dry. It is cobbly loam or cobbly clay loam and is 20 to 35 percent clay. The horizon is 5 to 10 percent subangular gravel, 10 to 20 percent subangular cobbles, and 0 to 50 percent subangular stones. Total rock fragment content is 15 to 35 percent.

Ninemile Series

The Ninemile series consists of shallow, well drained soils on lava plains. These soils formed in residuum derived from basalt with ash in the upper part. Slopes are 0 to 10 percent. The mean annual precipitation is about 11 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Ninemile sandy loam, 0 to 10 percent slopes; 400 feet north and 1,600 feet east of the southwest corner of sec. 34, T. 22 S., R. 20 E.

A1—0 to 2 inches; grayish brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) moist; weak thick platy structure; soft, very friable, nonsticky and nonplastic; many very fine and fine roots; many very fine and fine vesicular pores; 5 percent gravel, 5 percent cobbles, and 2 percent stones; neutral (pH 7.2); abrupt wavy boundary.

A2—2 to 7 inches; grayish brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) moist; moderate thick platy structure; soft, very friable, nonsticky and nonplastic; common fine roots and few medium roots; many fine and medium vesicular pores; 5 percent gravel and 5 percent cobbles; mildly alkaline (pH 7.6); abrupt wavy boundary.

2Bt1—7 to 12 inches; pale brown (10YR 6/3) clay, brown (10YR 4/3) moist; strong fine angular blocky structure; very hard, very firm, sticky and plastic; many fine roots; many very fine and common fine tubular pores; few faint clay films on faces of peds and in pores; 5 percent gravel and 5 percent cobbles; mildly alkaline (pH 7.8); clear wavy boundary.

2Bt2—12 to 19 inches; yellowish brown (10YR 5/4) gravelly clay, dark yellowish brown (7.5YR 4/4) moist; strong fine angular blocky structure; very hard, very firm, sticky and plastic; few very fine and fine roots; few very fine and fine tubular pores; common faint clay films on faces of peds and in pores; 15 percent gravel and 5 percent cobbles; moderately alkaline (pH 8.4); abrupt irregular boundary.

2R—19 inches; fractured basalt; thin, discontinuous coating of opal on surface and in fractures.

Depth to bedrock is 10 to 20 inches. The mollic epipedon is 7 to 12 inches thick.

The A horizon has value of 2 or 3 when moist and 4 or 5 when dry, and it has chroma of 2 or 3 when moist or dry. It is sandy loam or very cobbly loam. It is 2 to 7 inches thick.

The 2Bt horizon has hue of 7.5YR or 10YR when moist or dry, value of 4 when moist and 5 or 6 when dry, and chroma of 3 or 4 when dry. The horizon is gravelly clay or clay.

Omahaling Series

The Omahaling series consists of very deep, somewhat poorly drained soils on flood plains. These soils formed in ash over older alluvium. Slopes are 0 to 5 percent. The mean annual precipitation is about 15 inches, and the mean annual air temperature is about 45 degrees F.

Typical pedon of Omahaling fine sandy loam, 0 to 5 percent slopes; 400 feet south and 100 feet west of the northeast corner of the SW1/4 of sec. 26, T. 14 S., R. 10 E.

Ap—0 to 4 inches; very dark brown (10YR 2/2) fine sandy loam, dark grayish brown (10YR 4/2) dry; moderate very fine granular structure; slightly hard, friable, nonsticky and nonplastic; common very fine roots; common very fine irregular pores; mildly alkaline (pH 7.4); abrupt wavy boundary.

AC—4 to 19 inches; very dark brown (10YR 2/2) fine sandy loam, dark grayish brown (10YR 4/2) dry; massive; slightly hard, friable, nonsticky and nonplastic; few very fine, fine, and medium roots; many very fine irregular pores; 5 percent rounded gravel; mildly alkaline (pH 7.4); abrupt wavy boundary.

2C1—19 to 23 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; common fine distinct dark yellowish brown mottles; weak thin platy structure; slightly hard, friable, nonsticky and nonplastic; few very fine roots; common very fine tubular pores; mildly alkaline (pH 7.6); abrupt wavy boundary.

2C2—23 to 29 inches; very dark brown (10YR 2/2) gravelly sand, dark gray (10YR 4/1) dry; common medium distinct dark yellowish brown mottles; single grain; loose, nonsticky and nonplastic; few very fine roots; few very fine irregular pores; 20 percent subrounded gravel; 5 percent iron-cemented lenses 1 to 2 centimeters thick; mildly alkaline (pH 7.6); abrupt wavy boundary.

2C3—29 to 48 inches; very dark brown (10YR 2/2) silt loam with lenses of very fine sandy loam throughout, dark grayish brown (10YR 4/2) dry; common fine distinct dark yellowish brown mottles generally adjacent to roots and lining pores; massive; slightly hard, friable, sticky and nonplastic; few medium roots; few fine irregular pores; mildly alkaline (pH 7.6); abrupt wavy boundary.

3C4—48 to 60 inches; very dark brown (10YR 2/2) extremely gravelly coarse sand, dark gray (10YR 4/1) dry; massive; loose, nonsticky and nonplastic; 80 percent rounded gravel and 5 percent rounded cobbles; mildly alkaline (pH 7.8).

Depth to bedrock is 60 inches or more. Depth to mottles that have chroma of 2 or less is 15 to 30 inches.

The A horizon has hue of 10YR, value of 2 when moist and 4 or 5 when dry, and chroma of 2 when moist or dry. It is 0 to 10 percent rounded gravel. It is neutral or mildly alkaline.

The 2C horizon has hue of 10YR, value of 2 or 3 when moist and 4 or 5 when dry, and chroma of 2 when moist and 1 or 2 when dry. It is 0 to 25 percent gravel. It has common distinct or prominent mottles. The horizon is silt loam, very fine sandy loam, or loam and has strata of sand. It is neutral or mildly alkaline.

The 3C horizon has hue of 10YR, value of 2 or 3 when moist and 4 when dry, and chroma of 2 or 3 when moist and 1 or 2 when dry. It is 60 to 80 percent gravel and 5 to 15 percent cobbles. Total coarse fragment content is 65 to 95 percent.

Parrego Series

The Parrego series consists of moderately deep, well drained soils on mountains. These soils formed in ash over colluvium and residuum. Slopes are 0 to 50 percent. The mean annual precipitation is about 20 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Parrego sandy loam in an area of Windego-Parrego complex, 0 to 15 percent slopes; on Forest Service Road 1193-130, 0.2 mile east of junction with Forest Service Road 1193; in the NW1/4NW1/4 of sec. 35, T. 12 S., R. 10 E.

Oi—3 inches to 0; litter of conifer needles and twigs.

A1—0 to 5 inches; dark brown (10YR 3/3) sandy loam, brown (10YR 5/3) dry; weak medium granular structure; slightly hard, friable, nonsticky and nonplastic; many fine and very fine roots and few coarse roots; many fine interstitial pores; 25 percent soft rock fragments; 10 percent clay; neutral (pH 6.8); clear wavy boundary.

2A2—5 to 13 inches; brown (7.5YR 4/4) loam, brown (7.5YR 5/4) dry; weak medium subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; common fine, medium, and coarse roots; many very fine interstitial pores; 25 percent soft rock fragments; 20 percent clay; neutral (pH 7.0); clear wavy boundary.

2Btb—13 to 24 inches; brown (7.5YR 4/4) clay loam, brown (7.5YR 5/4) dry; weak medium subangular blocky structure; hard, firm, slightly sticky and slightly plastic; common medium and coarse roots; many fine and very fine tubular pores; common distinct clay films on faces of peds and in pores; 50 percent soft rock fragments; 30 percent clay; neutral (pH 7.0); clear wavy boundary.

2Cr—24 inches; weathered tuff.

Depth to the paralithic contact is 20 to 40 inches.

The O horizon is 1 to 3 inches thick except in areas that have been disturbed.

The A horizon has value of 2 or 3 when moist and 4 or 5 when dry, and it has chroma of 3 when moist or dry. It is 5 to 18 percent clay. Total soft rock fragment content is 15 to 30 percent. The horizon is slightly acid or neutral. It is 4 to 7 inches thick.

The 2A2 horizon has chroma of 3 or 4 when moist or dry. It is 10 to 25 percent clay. Total soft rock fragment content is 15 to 30 percent.

The 2Btb horizon has chroma of 3 to 5 when dry. The horizon is clay loam or loam and is 20 to 35 percent clay. Total soft rock fragment content is 35 to 60 percent.

Plainview Series

The Plainview series consists of well drained soils that are moderately deep to glacial outwash. These soils are on outwash plains. They formed in ash over glacial outwash. Slopes are 0 to 8 percent. The mean annual precipitation is about 11 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Plainview sandy loam, 0 to 3 percent slopes; 2,000 feet east and 500 feet south of the northwest corner of sec. 6, T. 16 S., R. 11 E.

A1—0 to 11 inches; dark grayish brown (10YR 4/2) sandy loam, very dark brown (10YR 2/2) moist; weak fine subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; common very fine and fine roots; many very fine irregular pores; neutral (pH 6.8); clear smooth boundary.

A2—11 to 16 inches; brown (10YR 5/3) sandy loam, very dark grayish brown (10YR 3/2) moist; weak fine and medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; common very fine and fine roots; common very fine and fine vesicular pores; 5 percent gravel; neutral (pH 7.0); gradual smooth boundary.

Bw1—16 to 23 inches; brown (10YR 5/3) sandy loam, dark brown (10YR 3/3) moist; weak fine and medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; common very fine and fine roots; common very fine and fine vesicular pores; 10 percent gravel; neutral (pH 7.2); clear smooth boundary.

2Bw2—23 to 27 inches; pale brown (10YR 6/3) very gravelly sandy loam, very dark grayish brown (10YR 3/2) moist; weak medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few very fine and fine roots; common very fine and fine vesicular pores; 35 percent gravel; neutral (pH 7.2); gradual smooth boundary.

2Bw3—27 to 33 inches; light brownish gray (10YR 6/2) very gravelly sandy loam, dark grayish brown (10YR 4/2) moist; weak medium subangular blocky structure; slightly hard, firm, nonsticky and nonplastic; common very fine and few fine roots; common very fine and fine vesicular pores; 55 percent gravel; mildly alkaline (pH 7.6); clear smooth boundary.

3C1—33 to 39 inches; pale brown (10YR 6/3) extremely gravelly sandy loam, dark grayish brown (10YR 4/2) moist; massive; slightly hard, friable, nonsticky and nonplastic; common very fine and fine roots; common very fine and fine irregular pores; 65 percent gravel and 10 percent cobbles; mildly alkaline (pH 7.6); clear smooth boundary.

3C2—39 to 55 inches; light brownish gray (10YR 6/2) very gravelly loamy sand, very dark grayish brown (10YR 3/2) and dark yellowish brown (10YR 4/4) moist; single grain; loose, nonsticky and nonplastic; common very fine and fine roots; common very fine and fine irregular pores; 50 percent gravel and 5 percent cobbles; mildly alkaline (pH 7.8); abrupt wavy boundary.

3Ckqm—55 to 60 inches; very dark grayish brown (10YR 3/2) and light gray (10YR 7/2) indurated duripan with 1-millimeter-thick silica lamellae and filaments of carbonates; strongly effervescent; massive; very hard.

Depth to the glacial outwash deposits (2Bw horizon) is 20 to 40 inches. Depth to bedrock is more than 60 inches. Depth to the strongly cemented or indurated duripan is 50 inches or more. The mantle of ash is 20 to 60 percent pumice sand (0.5 to 2.0 millimeters).

The A horizon has value of 4 or 5 when dry and 2 or 3 when moist, and it has chroma of 1 to 3 when moist or dry. The horizon is 0 to 10 percent gravel.

The Bw horizon has value of 5 or 6 when dry and 3 or 4 when moist, and it has chroma of 2 or 3 when moist or dry.

The 2Bw horizon has value of 5 or 6 when dry and 3 or 4 when moist, and it has chroma of 2 or 3 when moist or dry. It is 30 to 60 percent gravel and 0 to 10 percent cobbles. Total rock fragment content is 35 to 60 percent. The horizon is neutral or mildly alkaline.

The 3C horizon has value of 5 or 6 when dry and 3 or 4 when moist, and it has chroma of 2 or 3 when moist or dry. It is extremely gravelly sandy loam or very gravelly loamy sand and is 35 to 50 percent gravel and 5 to 15 percent cobbles. Total rock fragment content is 45 to 65 percent.

Prairie Series

The Prairie series consists of moderately deep, well drained soils on mountains. These soils formed in ash over colluvium and residuum. Slopes are 0 to 50 percent. The mean annual precipitation is about 30 inches, and the mean annual air temperature is about 42 degrees F.

Typical pedon of Prairie sandy loam in an area of Prairie-Gap complex, 0 to 15 percent slopes; on Forest Service Road 1140-680, 0.4 mile from junction with Forest Service Road 1140-610; in the SW¹/₄SE¹/₄ of sec. 13, T. 12 S., R. 9 E.

Oi—3 inches to 0; litter of ponderosa pine, Douglas fir, and white fir needles and twigs.

A1—0 to 7 inches; dark brown (10YR 3/3) sandy loam, brown (10YR 4/3) dry; weak medium granular structure; slightly hard, friable, nonsticky and nonplastic; many very fine and fine roots; many very fine irregular pores; 5 percent gravel; neutral (pH 6.8); gradual smooth boundary.

A2—7 to 16 inches; dark yellowish brown (10YR 3/4) sandy loam, brown (10YR 4/3) dry; moderate medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; common fine, medium, and coarse roots; many fine irregular pores; 5 percent gravel; neutral (pH 7.0); gradual smooth boundary.

2Btb1—16 to 22 inches; dark brown (10YR 3/3) gravelly loam, brown (10YR 4/3) dry; strong medium subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; few medium and coarse roots; common very fine tubular pores; few faint clay films in pores and on faces of peds; 15 percent gravel; neutral (pH 7.0); clear wavy boundary.

2Btb2—22 to 37 inches; dark brown (7.5YR 4/2) cobbly loam, brown (7.5YR 5/4) dry; strong medium subangular blocky structure; hard, firm, slightly sticky and slightly plastic; few coarse roots; few fine irregular pores; many faint clay films in pores and on faces of peds; 20 percent gravel, 5 percent cobbles, and 5 percent stones; neutral (pH 7.2); clear wavy boundary.

2Cr—37 inches; weathered basalt.

Depth to the paralithic contact is 20 to 40 inches. Depth to the buried argillic horizon is 14 to 20 inches.

The O horizon is 2 to 4 inches thick except in areas that have been disturbed.

The A horizon has hue of 10YR, value of 3 or 4 when moist and 4 or 5 when dry, and chroma of 3 or 4 when moist or dry. It is 10 to 18 percent clay and 0 to 10 percent gravel.

The 2Btb horizon has hue of 10YR and 7.5YR, value of 3 or 4 when moist and 4 or 5 when dry, and chroma of 2 to 4 when moist and 3 or 4 when dry. The horizon is gravelly loam and cobbly loam and is 18 to 27 percent clay. It is 10 to 20 percent gravel and 5 to 15 percent cobbles and stones. Total rock fragment content is 15 to 35 percent.

Redcliff Series

The Redcliff series consists of moderately deep, well drained soils on hills and canyonsides. These soils formed in colluvium. Slopes are 0 to 65 percent. The mean annual precipitation is about 9 inches, and the mean annual air temperature is about 47 degrees F.

Typical pedon for Redcliff very gravelly loam in an area of Lickskillet-Redcliff very gravelly loams, 30 to 60 percent south slopes; 300 feet south and 300 feet east of the northwest corner of the NE¹/₄ of sec. 24, T. 13 S., R. 13 E.

A1—0 to 3 inches; brown (10YR 4/3) very gravelly loam, very dark brown (10YR 2/2) moist; weak very fine granular structure; slightly hard, very friable, slightly sticky and nonplastic; few very fine roots; many very fine interstitial pores; 45 percent gravel; neutral (pH 6.8); clear wavy boundary.

A2—3 to 13 inches; dark grayish brown (10YR 4/2) very gravelly loam, very dark grayish brown (10YR 3/2) moist; weak fine subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; many very fine and fine roots and few medium roots; many very fine interstitial pores; 55

percent gravel; neutral (pH 6.8); clear smooth boundary.

AB—13 to 19 inches; brown (10YR 4/3) very gravelly loam, very dark grayish brown (10YR 3/2) moist; weak fine subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; few very fine and fine roots; many very fine tubular pores; 55 percent gravel; neutral (pH 6.8); gradual smooth boundary.

Bw—19 to 25 inches; dark yellowish brown (10YR 4/4) extremely gravelly clay loam, dark yellowish brown (10YR 3/4) moist; weak medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few very fine roots; few very fine tubular pores; 75 percent gravel; neutral (pH 6.8); clear smooth boundary.

R—25 inches; rhyolite.

Depth to bedrock is 20 to 40 inches. The particle-size control section averages more than 18 percent clay.

The A horizon has chroma of 2 or 3 when moist or dry. It is 15 to 60 percent rock fragments. The horizon is cobbly sandy loam or very gravelly loam.

The Bw horizon has value of 4 or 5 when dry and chroma of 3 or 4 when moist or dry. It is 35 to 85 percent rock fragments. The horizon is extremely gravelly loam, extremely gravelly clay loam, very cobbly sandy loam, extremely cobbly sandy loam, very cobbly loam, or extremely cobbly loam and is 10 to 30 percent clay. It is neutral or mildly alkaline.

Redmond Series

The Redmond series consists of moderately deep, well drained soils on lava plains. These soils formed in ash. Slopes are 0 to 15 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Redmond sandy loam, 0 to 3 percent slopes; in the SW$^1/_4$SW$^1/_4$SE$^1/_4$ of sec. 11, T. 15 S., R. 13 E.

A—0 to 12 inches; grayish brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) moist; moderate very fine granular structure; loose, very friable, nonsticky and nonplastic; common very fine roots and few fine roots; many fine interstitial pores; 10 percent gravel and 5 percent cobbles; neutral (pH 7.0); clear smooth boundary.

2Bwb—12 to 17 inches; grayish brown (10YR 5/2) loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky structure; slightly hard, firm, slightly sticky and slightly plastic; few very fine and fine roots; common very fine tubular pores; 5 percent subangular gravel and 5 percent subangular cobbles; mildly alkaline (pH 7.4); clear wavy boundary.

2Bqb—17 to 21 inches; grayish brown (10YR 5/2) loam, dark brown (10YR 3/3) moist; moderate coarse subangular blocky structure; hard, very firm, slightly sticky and slightly plastic; few very fine roots; common very fine tubular pores; few pendants of calcium carbonate and opal on underside of gravel; 5 percent subangular gravel and 5 percent subangular cobbles; mildly alkaline (pH 7.8); abrupt irregular boundary.

2R—21 inches; basalt.

Depth to bedrock is 20 to 40 inches.

The A horizon has value of 2 or 3 when moist, and it has chroma of 2 or 3 when moist or dry. The horizon is sandy loam and is 5 to 15 percent clay. It is 0 to 10 percent gravel and 0 to 5 percent cobbles.

The 2B horizon has value of 5 or 6 when dry and 3 or 4 when moist. It is loam, clay loam, or cobbly loam and is 18 to 30 percent clay. The horizon is 0 to 10 percent gravel and 0 to 10 percent cobbles. It is 0 to 15 percent durinodes. Some rock fragments have coatings of calcium carbonate and opal. The horizon is neutral or mildly alkaline.

Redslide Series

The Redslide series consists of moderately deep, well drained soils on hills and canyonsides. These soils formed in ash and colluvium. Slopes are 15 to 50 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Redslide stony sandy loam in an area of Redslide-Lickskillet complex, 30 to 50 percent north slopes; above O.B. Riley Road; 700 feet north and 800 feet west of the southeast corner of sec. 6, T. 17 S., R. 12 E.

A1—0 to 4 inches; grayish brown (10YR 5/2) stony sandy loam, very dark grayish brown (10YR 3/2) moist; weak medium platy structure; slightly hard, friable, slightly sticky and nonplastic; common medium roots and many very fine and fine roots; many very fine irregular pores; 5 percent gravel, 5 percent cobbles, and 15 percent stones; neutral (pH 7.0); clear smooth boundary.

A2—4 to 21 inches; brown (10YR 5/3) very cobbly sandy loam, very dark grayish brown (10YR 3/2) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and nonplastic; common very fine, fine, and medium roots; many very fine irregular pores; 20 percent gravel and 30 percent cobbles; neutral (pH 7.2); clear smooth boundary.

Bk—21 to 34 inches; brown (10YR 5/3) extremely cobbly sandy loam, dark brown (10YR 3/3) moist; massive; slightly hard, friable, slightly sticky and nonplastic; common fine, medium, and coarse roots; many very fine irregular pores; 20 percent gravel and 45 percent cobbles; coatings of lime on underside of rock fragments; slightly effervescent; mildly alkaline (pH 7.6); abrupt wavy boundary.

R—34 inches; fractured rhyolite; coatings of lime on bedrock and in fractures.

Depth to bedrock is 20 to 40 inches. The content of pumice sand (0.5 to 2.0 millimeters) is 15 to 30 percent.

The A horizon has value of 4 or 5 when dry and 2 or 3 when moist, and it has chroma of 2 or 3 when moist or dry. The horizon is sandy loam or loam and is 5 to 20 percent gravel, 5 to 40 percent cobbles, and 0 to 20 percent stones. Total rock fragment content ranges from 20 to 60 percent.

The Bk horizon has value of 5 or 6 when dry and 3 or 4 when moist, and it has chroma of 2 or 3 when moist or dry. It is sandy loam or loam and is 0 to 20 percent gravel, 40 to 60 percent cobbles, and 0 to 5 percent stones. Total rock fragment content is 50 to 70 percent. The horizon is neutral or mildly alkaline.

Reluctan Series

The Reluctan series consists of moderately deep, well drained soils on lava plains. These soils formed in residuum with ash in the upper part. Slopes are 1 to 20 percent. The mean annual precipitation is about 12 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Reluctan sandy loam, 1 to 8 percent slopes; in the SE$^1/_4$NW$^1/_4$ of sec. 18, T. 22 S., R. 21 E.

A1—0 to 4 inches; grayish brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) moist; weak thick platy structure; soft, very friable, nonsticky and nonplastic; many very fine and fine roots; many fine vesicular pores; 5 percent gravel and 2 percent stones; neutral (pH 7.2) clear wavy boundary.

A2—4 to 10 inches; brown (10YR 4/3) sandy loam, dark brown (10YR 3/3) moist; weak fine subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; many very fine and fine roots; common fine tubular pores; 5 percent gravel and 5 percent cobbles; neutral (pH 7.2); clear wavy boundary.

2Bt1—10 to 21 inches; brown (10YR 5/3) gravelly clay loam, dark brown (10YR 4/3) moist; weak to moderate medium subangular blocky structure; very hard, firm, sticky and plastic; common fine roots and few medium roots; common fine tubular pores; common thin clay films on peds and lining pores; 10 percent gravel and 5 percent cobbles; mildly alkaline (pH 7.4); abrupt wavy boundary.

2Bt2—21 to 25 inches; pale brown (10YR 6/3) gravelly clay loam, yellowish brown (10YR 5/4) moist; moderate medium subangular blocky structure; hard, very firm, sticky and plastic; few fine and medium roots; few fine tubular pores; 20 percent gravel; few thin clay films on peds and lining pores; mildly alkaline (pH 7.8); abrupt wavy boundary.

2R—25 inches; fractured basalt; thin coating of opal and calcium carbonate in fractures.

Depth to bedrock is 20 to 40 inches.

The A horizon has value of 4 or 5 when dry and chroma of 2 or 3 when moist or dry. The horizon is sandy loam or loam. It is neutral or mildly alkaline.

The 2Bt horizon has value of 4 or 5 when moist and 5 or 6 when dry, and it has chroma of 3 or 4 when moist or dry. The horizon is gravelly loam or gravelly clay loam. Rock fragment content is 15 to 35 percent. Clay content is 25 to 35 percent. The horizon is mildly alkaline or moderately alkaline.

Reuter Series

The Reuter series consists of shallow, well drained soils on hills. These soils formed in colluvium over volcaniclastic sediment of the Deschutes Formation. Slopes are 0 to 30 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Reuter sandy loam in an area of Caphealy-Reuter complex, 15 to 30 percent slopes; on the east side of roadcut; 300 feet north and 1,000 feet west of the southeast corner of the NW$^1/_4$ of sec. 36, T. 12 S., R. 12 E.

A1—0 to 3 inches; grayish brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) moist; weak very fine granular structure; slightly hard, friable, nonsticky and nonplastic; many very fine and fine roots and few medium roots; many very fine interstitial pores; 5 percent gravel; mildly alkaline (pH 7.4); clear smooth boundary.

A2—3 to 12 inches; brown (10YR 5/3) sandy loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; few very fine roots; many very fine interstitial pores; 5 percent gravel; mildly alkaline (pH 7.6); clear smooth boundary.

2Cr—12 to 24 inches; weathered tuffaceous sandstone; gradual wavy boundary.

2R—24 inches; welded tuff of the Deschutes Formation.

Depth to the paralithic contact is 10 to 20 inches. Depth to hard bedrock is 20 inches or more. The profile is about 10 to 25 percent pumice sand throughout. It is neutral or mildly alkaline throughout.

The A horizon has hue of 10YR, value of 5 when dry and 2 or 3 when moist, and chroma of 2 or 3 when moist or dry. It is 0 to 10 percent rock fragments.

Ruckles Series

The Ruckles series consists of shallow, well drained soils on canyonsides. These soils formed in colluvium. Slopes are 15 to 80 percent. The mean annual precipitation is about 9 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Ruckles extremely cobbly loam in an area of Simas-Ruckles complex, 15 to 40 percent south slopes, along roadcut; 200 feet west and 500 feet north of the southeast corner of the NW1/4 of sec. 11, T. 13 S., R. 11 E.

A1—0 to 3 inches; dark grayish brown (10YR 4/2) extremely cobbly loam, very dark brown (10YR 2/2) moist; weak thin platy structure; slightly hard, very friable, nonsticky and nonplastic; many very fine and fine roots; many very fine interstitial pores; 20 percent clay; 20 percent gravel, 30 percent cobbles, and 15 percent stones; mildly alkaline (pH 7.4); gradual wavy boundary.

A2—3 to 9 inches; dark grayish brown (10YR 4/2) extremely cobbly loam, very dark brown (10YR 2/2) moist; weak fine subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; common very fine and fine roots; many very fine interstitial pores; 20 percent clay; 20 percent gravel, 30 percent cobbles, and 15 percent stones; mildly alkaline (pH 7.6); gradual wavy boundary.

Bt1—9 to 14 inches; brown (10YR 4/3) extremely cobbly clay, very dark grayish brown (10YR 3/2) moist; moderate fine subangular blocky structure; hard, friable, slightly sticky and slightly plastic; common very fine, fine, and medium roots; many very fine interstitial pores and common very fine tubular pores; few faint clay films in pores and on faces of peds; 40 percent clay; 20 percent gravel, 30 percent cobbles, and 15 percent stones; mildly alkaline (pH 7.6); clear wavy boundary.

Bt2—14 to 18 inches; light yellowish brown (10YR 6/4) cobbly clay, dark grayish brown (10YR 4/2) moist; strong fine and medium subangular blocky structure; very hard, firm, slightly sticky and plastic; few fine, medium, and coarse roots; many fine interstitial pores and common fine tubular pores, many distinct brown (7.5YR 5/3) clay films in pores and on faces of peds; 60 percent clay; 10 percent gravel and 20 percent cobbles; mildly alkaline (pH 7.6); clear smooth boundary.

Cr—18 to 19 inches; weathered tuff; abrupt wavy boundary.

R—19 inches; welded tuff.

Depth to bedrock is 10 to 20 inches. The mollic epipedon is 7 to 12 inches thick. The particle-size control section averages more than 50 percent clay and more than 45 percent rock fragments.

The A horizon has value of 4 or 5 when dry and 2 or 3 when moist, and it has chroma of 2 or 3 when moist or dry. The horizon is 20 to 27 percent clay. It is 5 to 40 percent gravel, 20 to 60 percent cobbles, and 0 to 15 percent stones. Total rock fragment content is 60 to 75 percent.

The Bt1 horizon has value of 3 or 4 when moist and chroma of 2 to 4 when moist or dry. It is extremely cobbly clay loam or extremely cobbly clay and is 35 to 50 percent clay. The horizon is 5 to 40 percent gravel, 20 to 60 percent cobbles, and 0 to 15 percent stones. Total rock fragment content is 60 to 75 percent.

The Bt2 horizon has value of 5 or 6 when dry and chroma of 2 to 4 when moist or dry. It is cobbly clay or very cobbly clay and is 45 to 65 percent clay. The horizon is 5 to 25 percent gravel and 15 to 35 percent cobbles. Total rock fragment content is 30 to 60 percent.

Schrier Series

The Schrier series consists of very deep, well drained soils on hills. These soils formed in loess over colluvium. Slopes are 15 to 60 percent. The mean annual precipitation is about 14 inches, and the mean annual air temperature is about 47 degrees F.

Typical pedon of Schrier silt loam in an area of Schrier-Tub complex, 30 to 60 percent north slopes; 1,500 feet north and 200 feet west of the southeast corner of sec. 36, T. 13 S., R. 13 E.

A1—0 to 4 inches; very dark grayish brown (10YR 3/2) silt loam, brown (10YR 4/3) dry; weak fine granular structure; slightly hard, friable, slightly sticky and nonplastic; many very fine roots; many very fine interstitial pores; 10 percent gravel; neutral (pH 6.8); clear wavy boundary.

A2—4 to 16 inches; very dark grayish brown (10YR 3/2) silt loam, brown (10YR 4/3) dry; moderate fine subangular blocky structure; slightly hard, friable, slightly sticky and nonplastic; common fine and medium roots; many very fine interstitial pores; 10 percent gravel; neutral (pH 6.8); abrupt wavy boundary.

2BA—16 to 21 inches; dark brown (10YR 3/3) very gravelly silt loam, brown (10YR 4/3) dry; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and nonplastic; common very fine, fine, and medium roots; many very fine tubular pores; 40 percent gravel; neutral (pH 7.2); clear wavy boundary.

2Bw—21 to 36 inches; dark brown (10YR 4/3) silt loam, brown (10YR 5/3) dry; weak medium subangular structure; slightly hard, friable, sticky and nonplastic; few very fine and medium roots; many very fine tubular pores; 10 percent gravel; mildly alkaline (pH 7.4); gradual smooth boundary.

2Bk—36 to 42 inches; dark brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; weak medium subangular structure; slightly hard, friable, sticky and nonplastic; few fine and medium roots; many very fine tubular pores; 10 percent gravel; strongly effervescent; seams and nodules of secondary carbonates, coatings of carbonates on gravel; moderately alkaline (pH 8.2); clear wavy boundary.

3Ck—42 to 60 inches; dark brown (10YR 4/3) extremely gravelly fine sand, pale brown (10YR 6/3) dry; single grain; loose, very friable, nonsticky and nonplastic; many very fine interstitial pores; 70 percent gravel; seams and nodules of secondary carbonates, coatings of carbonates on gravel; strongly effervescent; moderately alkaline (pH 8.4).

Depth to bedrock is more than 60 inches. Depth to secondary carbonates is 30 to 40 inches. The mollic epipedon is 20 to 30 inches thick.

The A horizon has value of 4 or 5 when dry and chroma of 2 or 3 when moist or dry. It is 0 to 15 percent gravel.

The 2BA horizon has value of 4 or 5 when dry and chroma of 2 or 3 when moist or dry. It is 35 to 45 percent gravel and 0 to 10 percent cobbles. Total rock fragment content is 35 to 55 percent.

The 2Bw horizon has value of 5 or 6 when dry and chroma of 2 or 3 when moist or dry. It is 0 to 15 percent gravel. It is loam or silt loam.

The 2Bk horizon has value of 5 or 6 when dry and chroma of 2 or 3 when moist or dry. It is 0 to 15 percent gravel. It has coatings of carbonates on gravel or has seams and nodules of carbonates. The horizon is loam or silt loam.

The 3Ck horizon has value of 4 or 5 when moist and 6 or 7 when dry, and it has chroma of 2 or 3 when moist or dry. It is 65 to 80 percent gravel.

Searles Series

The Searles series consists of moderately deep, well drained soils on lava plains and hills. These soils formed in ash over residuum. Slopes are 0 to 30 percent. The mean annual precipitation is about 11 inches, and the mean annual air temperature is about 49 degrees F.

Typical pedon of Searles sandy loam in an area of Holmzie-Searles complex, 0 to 15 percent slopes; in the SW1/4NW1/4 of sec. 32, T. 14 S., R. 12 E.

A1—0 to 3 inches; grayish brown (10YR 5/2) sandy loam, very dark brown (10YR 2/2) moist; weak very fine granular structure; loose, very friable, nonsticky and nonplastic; few fine roots; common fine interstitial pores; neutral (pH 7.2); clear smooth boundary.

A2—3 to 7 inches; grayish brown (10YR 5/2) sandy loam, very dark brown (10YR 2/2) moist; weak medium subangular blocky structure; loose, very friable, nonsticky and nonplastic; few fine and medium roots; few fine interstitial pores; 10 percent cobbles; neutral (pH 7.2); clear wavy boundary.

BA—7 to 13 inches; brown (10YR 5/3) loam, very dark grayish brown (10YR 3/2) moist; weak medium and coarse subangular blocky structure; soft, friable, slightly sticky and nonplastic; few fine, medium, and coarse roots; few fine interstitial pores; 10 percent gravel; neutral (pH 7.2); clear smooth boundary.

2Bt1—13 to 15 inches; brown (10YR 5/3) very gravelly loam, very dark grayish brown (10YR 3/2) moist; weak fine subangular blocky structure; soft, friable, slightly sticky and slightly plastic; few fine roots; common fine interstitial and tubular pores; few faint clay films on peds and in pores; 30 percent gravel and 10 percent cobbles; mildly alkaline (pH 7.4); gradual wavy boundary.

2Bt2—15 to 24 inches; yellowish brown (10YR 5/4) very gravelly clay loam, dark yellowish brown (10YR 4/4) moist; weak fine subangular blocky structure; slightly hard, firm, sticky and plastic; few fine roots; common fine interstitial and tubular pores; 35 percent gravel and 15 percent cobbles; common faint clay films on peds and in pores; mildly alkaline (pH 7.4); clear smooth boundary.

2R—24 inches; basalt; discontinuous coatings of opal and carbonates in fractures.

Depth to bedrock is 20 to 40 inches. The particle-size control section averages more than 50 percent rock fragments.

The A horizon has value of 2 or 3 when moist, and it has chroma of 2 or 3 when moist or dry. It is 4 to 7 inches thick.

The BA horizon has chroma of 2 or 3 when moist or dry. It is loam or gravelly loam. It is neutral or mildly alkaline.

The 2Bt horizon has value of 5 or 6 when dry and 3 or 4 when moist, and it has chroma of 3 or 4 when dry and 2 to 4 when moist. It is very gravelly loam, very gravelly clay loam, or very cobbly clay loam and is 25 to 35 percent clay. It is 20 to 35 percent gravel and 10 to 30 percent cobbles. Total rock fragment content is 40 to 60 percent. Some pedons have weakly cemented nodules in the lower part of the horizon. The horizon is neutral or mildly alkaline.

Shanahan Series

The Shanahan series consists of very deep, somewhat excessively drained soils on pumice-mantled lava plains and hills. These soils formed in ash over colluvium and old alluvium. Slopes are 0 to 30 percent. The mean annual precipitation is about 20 inches, and the mean annual air temperature is about 43 degrees F.

Typical pedon of Shanahan loamy coarse sand, 0 to 15 percent slopes; about 200 feet from road to Lapine State Recreation Area; in the NW1/4NW1/4 of sec. 11, T. 21 S., R. 10 E.

Oi—1 inch to 0; litter of ponderosa pine needles and twigs.

A1—0 to 3 inches; dark brown (10YR 4/3) loamy coarse sand, brown (10YR 4/3) dry; weak fine granular structure; soft, very friable, nonsticky and nonplastic; many very fine and fine roots; many very fine interstitial pores; 5 percent pumiceous gravel; 50 percent pumice (0.5 to 2.0 millimeters); neutral (pH 6.8); gradual smooth boundary.

A2—3 to 8 inches; dark yellowish brown (10YR 4/4) loamy coarse sand, brown (10YR 4/3) dry; single grain; soft, very friable, nonsticky and nonplastic; common very fine and fine roots and few medium roots; many very fine interstitial pores; 10 percent pumiceous gravel; 50 percent pumice (0.5 to 2.0 millimeters); neutral (pH 6.8); clear smooth boundary.

AC—8 to 13 inches; yellowish brown (10YR 5/4) gravelly loamy coarse sand, pale brown (10YR 6/3) dry; single grain; loose, nonsticky and nonplastic; common very fine roots and few fine, medium, and coarse roots; many very fine interstitial pores; 30 percent pumiceous gravel; 70 percent pumice (0.5 to 2.0 millimeters); neutral (pH 6.8); clear smooth boundary.

C1—13 to 20 inches; yellowish brown (10YR 5/4) and brownish yellow (10YR 6/6) coarse sand, very pale brown (10YR 7/3 and 8/4) dry; single grain; loose, nonsticky and nonplastic; few very fine and fine roots; many very fine interstitial pores; 5 percent pumiceous gravel; 60 percent pumice (0.5 to 2.0 millimeters); few krotovinas (2.5 centimeters in diameter); neutral (pH 6.8); clear wavy boundary.

C2—20 to 26 inches; brown (10YR 5/3) loamy coarse sand, light yellowish brown (10YR 6/4) dry; single grain; loose, nonsticky and nonplastic; few very fine, fine, and medium roots; many very fine interstitial pores; 5 percent pumiceous gravel; 60 percent pumice (0.5 to 2.0 millimeters); neutral (pH 6.8); abrupt wavy boundary.

2Bwb1—26 to 37 inches; dark brown (10YR 3/3) sandy loam, yellowish brown (10YR 5/4) dry; weak fine and medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few fine, medium, and coarse roots; many very fine interstitial pores; 10 percent gravel; 30 percent pumice (0.5 to 2.0 millimeters); common medium distinct iron and manganese mottles; neutral (pH 6.6); gradual wavy boundary.

2Bwb2—37 to 44 inches; dark brown (10YR 3/3) gravelly sandy loam, brown (10YR 5/3) dry; weak medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few fine, medium, and coarse roots; many very fine interstitial pores; 25 percent gravel; 15 percent pumice (0.5 to 2.0 millimeters); common medium distinct iron and manganese mottles; neutral (pH 6.6); gradual wavy boundary.

3C—44 to 61 inches; very dark gray (10YR 3/1) very gravelly coarse sand, dark gray (10YR 4/1) dry; massive; loose, nonsticky and nonplastic; many very fine interstitial pores; 50 percent gravel; 45 percent pumice (0.5 to 2.0 millimeters); neutral (pH 6.8).

Depth to the 2Bwb horizon is 20 to 40 inches. Depth to bedrock is more than 60 inches. Depth to the 3C horizon is 40 to 60 inches or more. The profile is slightly acid or neutral.

The O horizon is 1 to 3 inches thick except in areas that have been disturbed.

The upper part of the A horizon has value of 3 or 4 when moist and 4 or 5 when dry, and the lower part has value of 4 to 6 when moist or dry. The horizon has chroma of 2 to 4 when moist or dry. It is 5 to 15 percent pumiceous gravel and 40 to 60 percent pumice (0.5 to 2.0 millimeters).

The AC and C horizons have hue of 10YR or 2.5Y, value of 5 to 8 when moist and 6 to 8 when dry, and chroma of 1 to 8 when moist or dry. They are coarse sand, gravelly coarse sand, or gravelly loamy coarse sand. They are 5 to 30 percent pumiceous gravel and 40 to 70 percent pumice (0.5 to 2.0 millimeters).

The 2Bwb horizon has value of 3 or 4 when moist and 5 to 7 when dry, and it has chroma of 3 or 4 when moist or dry. It is sandy loam, loam, or gravelly sandy loam. It is 5 to 30 percent gravel and 10 to 40 percent pumice (0.5 to 2.0 millimeters).

The 3C horizon, where present, is variable material that includes pumice, lake sediment, and localized alluvium. The horizon is 35 to 60 percent gravel. It is very gravelly coarse sand or very gravelly loamy sand.

Shroyton Series

The Shroyton series consists of deep, well drained soils on mountains. These soils formed in ash. Slopes are 30 to 50 percent. The mean annual precipitation is about 40 inches, and the mean annual air temperature is about 42 degrees F.

Typical pedon of Shroyton loamy sand, 30 to 50 percent slopes; in the southwest corner of the SE$^1/_4$ of sec. 6, T. 17 S., R. 10 E.

Oi—2 inches to 0; ponderosa pine and white fir needles and twigs.

A1—0 to 2 inches; dark brown (7.5YR 3/2) loamy sand, brown (7.5YR 5/4) dry; weak fine granular structure; loose, nonsticky and nonplastic; common very fine and fine roots; many very fine and fine irregular pores; 2 percent gravel; 35 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.0); gradual wavy boundary.

A2—2 to 15 inches; dark brown (7.5YR 3/2) loamy sand, brown (7.5YR 5/4) dry; weak fine granular structure; loose, nonsticky and nonplastic; common very fine and fine roots; many very fine and fine irregular pores; 2 percent gravel; 35 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.0); clear irregular boundary.

2Bw1—15 to 31 inches; strong brown (7.5YR 4/6) gravelly coarse sandy loam, brown (7.5YR 5/4) dry; weak medium subangular blocky structure; soft, very friable, nonsticky and nonplastic; common very fine and fine roots and few medium and coarse roots; common very fine and fine irregular pores and common fine vesicular pores; 30 percent gravel; 30 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.0); clear wavy boundary.

3Bw2—31 to 55 inches; dark brown (10YR 3/3) gravelly sandy loam, yellowish brown (10YR 5/4) dry; moderate medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; common fine and medium roots; common very fine and fine irregular pores and common fine vesicular pores; 30 percent gravel; 40 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.0); abrupt irregular boundary.

4R—55 inches; andesite.

Depth to bedrock is 40 to 60 inches.

The A horizon has value of 2 or 3 when moist and 4 or 5 when dry, and it has chroma of 2 or 3 when moist and 3 or 4 when dry. The horizon is 0 to 10 percent gravel and 25 to 40 percent pumice (0.5 to 2.0 millimeters). It is 2 to 6 percent clay.

The Bw horizon has value of 3 or 4 when moist and 5 or 6 when dry, and it has chroma of 3, 4, or 6 when moist and 3 or 4 when dry. The horizon is gravelly sandy loam or gravelly coarse sandy loam. It is 15 to 30 percent gravel and 0 to 10 percent cobbles. Total rock fragment content is 15 to 35 percent. The horizon is 30 to 60 percent pumice (0.5 to 2.0 millimeters). It is 5 to 10 percent clay.

A gravelly loamy sand or sandy loam C horizon is present in some pedons.

Simas Series

The Simas series consists of very deep, well drained soils on hills and canyonsides. These soils formed in colluvium. Slopes are 0 to 80 percent. The mean annual precipitation is about 11 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Simas cobbly loam in an area of Simas-Ruckles-Rock outcrop complex, 40 to 80 percent south slopes, along roadcut; 1,000 feet south and 100 feet east of northwest corner of sec. 11, T. 13 S., R. 11 E.

A1—0 to 3 inches; dark grayish brown (10YR 4/2) cobbly loam, very dark brown (10YR 2/2) moist; moderate fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; many very fine interstitial pores; 25 percent cobbles; mildly alkaline (pH 7.4); clear wavy boundary.

A2—3 to 12 inches; dark grayish brown (10YR 4/2) cobbly loam, very dark brown (10YR 2/2) moist; moderate medium subangular blocky structure; slightly hard, firm, slightly sticky and slightly plastic; many very fine and fine roots; many very fine interstitial pores; 5 percent gravel and 10 percent cobbles; 30 percent clay; mildly alkaline (pH 7.4); clear wavy boundary.

2Bt1—12 to 19 inches; dark grayish brown (10YR 4/2) cobbly clay, dark brown (10YR 3/3) moist; strong coarse subangular blocky structure; hard, firm, sticky and plastic; few fine and medium roots; many fine tubular pores; many faint clay films in pores and on faces of peds; 20 percent cobbles; 55 percent clay; mildly alkaline (pH 7.4); clear wavy boundary.

2Btk2—19 to 28 inches; brown (10YR 4/3) clay, dark yellowish brown (10YR 3/4) moist; strong coarse subangular blocky structure; very hard, very firm, sticky and plastic; few very fine roots; few very fine tubular pores; many prominent clay films in pores and on faces of peds; 60 percent clay; common medium irregular calcareous deposits on faces of peds and in fractures; slightly effervescent; mildly alkaline (pH 7.6); gradual wavy boundary.

2Btk3—28 to 37 inches; brown (10YR 4/3) clay, dark yellowish brown (10YR 3/4) moist; strong medium subangular blocky structure; very hard, very firm, sticky and plastic; few coarse roots; few very fine tubular pores; many prominent clay films in pores and on faces of peds; 60 percent clay; common medium irregular calcareous deposits on faces of peds and in fractures; slightly effervescent; moderately alkaline (pH 8.4); clear smooth boundary.

2Bk—37 to 60 inches; yellowish brown (10YR 5/3) gravelly clay, dark yellowish brown (10YR 3/4) moist; strong medium subangular blocky structure; very hard, very firm, sticky and plastic; many very fine tubular pores; many prominent clay films in pores and on faces of peds; 25 percent gravel and 5 percent cobbles; 50 percent clay; strongly effervescent; moderately alkaline (pH 7.9).

Depth to bedrock is more than 60 inches. Depth to carbonates is 10 to 30 inches.

The A horizon has value of 2 or 3 when moist and 4 or 5 when dry. It is silt loam or cobbly loam. The horizon is 0 to 10 percent gravel and 0 to 30 percent cobbles. It is neutral or mildly alkaline.

The 2Bt horizon has value of 2 or 3 when moist and 4 or 5 when dry, and it has chroma of 2 or 3. It is clay, cobbly clay, or gravelly clay. The horizon is 0 to 25 percent gravel and 0 to 30 percent cobbles. Total rock fragment content is 0 to 35 percent. The horizon is 50 to 60 percent clay. It is neutral or mildly alkaline.

The 2Btk horizon has value of 4 or 5 when dry and chroma of 3 or 4. It has few to many nodules or seams of carbonates. The horizon is mildly alkaline or moderately alkaline and is slightly effervescent or strongly effervescent. Texture and rock fragment content are similar to those of the 2Bt horizon.

The 2Bk horizon is gravelly clay loam, gravelly clay, or cobbly clay. It is 35 to 60 percent clay, 0 to 20 percent cobbles, and 10 to 30 percent gravel. It is moderately alkaline or strongly alkaline.

Sisters Series

The Sisters series consists of very deep, well drained soils on mountains. These soils formed in ash over colluvium and residuum. Slopes are 0 to 50 percent. The mean annual precipitation is about 25 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Sisters loamy sand in an area of Sisters-Yapoah complex, 0 to 15 percent slopes; 2,000 feet south and 300 feet east of the northwest corner of sec. 14, T. 17 S., R. 10 E.

Oi—2 inches to 0; litter of ponderosa pine needles.

A1—0 to 2 inches; very dark brown (10YR 2/3) loamy sand, dark yellowish brown (10YR 4/4) dry; weak fine granular structure; loose, nonsticky and nonplastic; common very fine and fine roots; many very fine interstitial pores; 5 percent gravel; 20 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.0); clear wavy boundary.

A2—2 to 11 inches; dark brown (10YR 3/3) loamy sand, yellowish brown (10YR 5/4) dry; weak fine granular structure; loose, nonsticky and nonplastic; common fine and coarse roots and many medium roots; many very fine interstitial pores; 10 percent gravel; 40 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.0); gradual wavy boundary.

C—11 to 23 inches; dark yellowish brown (10YR 3/4) loamy sand, yellowish brown (10YR 5/4) dry; single grain; loose, nonsticky and nonplastic; common fine, medium, and coarse roots; many very fine interstitial pores; 5 percent gravel; 40 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.0); gradual wavy boundary.

2Ab—23 to 35 inches; dark brown (7.5YR 3/4) sandy loam, brown (7.5YR 5/4) dry; weak fine subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; common fine and medium roots; many very fine interstitial pores; 10 percent gravel; 10 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.0); clear wavy boundary.

2Bwb1—35 to 47 inches; dark reddish brown (5YR 3/3) clay loam, brown (7.5YR 5/4) dry; weak coarse subangular blocky structure parting to weak thin platy; hard, firm, slightly sticky and slightly plastic; few fine roots; many fine and medium vesicular and tubular pores; 10 percent gravel; 10 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.2); gradual wavy boundary.

2Bwb2—47 to 60 inches; dark brown (7.5YR 3/4) loam, brown (7.5YR 5/4) dry; weak coarse subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few fine roots; many fine, medium, and coarse vesicular and tubular pores; 10 percent gravel; 10 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.2).

Depth to the buried loamy material (2Ab horizon) is 20 to 35 inches. Depth to bedrock is more than 60 inches.

The A horizon has value of 2 or 3 when moist and 4 or 5 when dry, and it has chroma of 2 or 3 when moist and 3 or 4 when dry. The horizon is 0 to 10 percent gravel and 20 to 50 percent pumice (0.5 to 2.0 millimeters). It is 2 to 8 percent clay.

The C horizon has hue of 7.5YR or 10YR, value of 3 or 4 when moist and 5 or 6 when dry, and chroma of 4 to 6 when moist or dry. It is 0 to 10 percent gravel and 20 to 50 percent pumice (0.5 to 2.0 millimeters). The horizon is 2 to 8 percent clay.

The 2Ab and 2Bwb horizons have hue of 5YR or 7.5YR and chroma of 3 or 4 when moist or dry. They are sandy loam, loam, or clay loam. They are 0 to 15 percent gravel, 18 to 30 percent clay, and 5 to 20 percent pumice (0.5 to 2.0 millimeters).

Smiling Series

The Smiling series consists of very deep, well drained soils on mountains. These soils formed in ash over colluvium. Slopes are 0 to 70 percent. The mean annual precipitation is about 30 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Smiling sandy loam, 0 to 15 percent slopes, in the SE1/4SE1/4NW1/4 of sec. 2, T. 13 S., R. 9 E.

Oi—1 inch to 0; litter of ponderosa pine needles and grasses.

A1—0 to 4 inches; very dark brown (7.5YR 2/2) sandy loam, dark brown (7.5YR 4/2) dry; moderate very fine granular structure; slightly hard, friable, nonsticky and nonplastic; many very fine and fine roots and common medium roots; many very fine irregular pores; 10 percent pumice; neutral (pH 7.0); clear smooth boundary.

A2—4 to 16 inches; dark brown (7.5YR 3/4) sandy loam, brown (7.5YR 4/2) dry; moderate very fine granular structure; slightly hard, friable, nonsticky and nonplastic; common very fine, fine, medium, and coarse roots; many very fine irregular pores; 10 percent pumice; neutral (pH 7.0); abrupt wavy boundary.

2Btb1—16 to 27 inches; dark brown (7.5YR 3/4) loam, brown (7.5YR 5/4) dry; weak medium and fine subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; few fine roots and common medium and coarse roots; common very fine tubular pores; few faint clay films on peds and in pores; 5 percent gravel; neutral (pH 7.0); gradual wavy boundary.

2Btb2—27 to 39 inches; dark brown (7.5YR 3/4) loam, brown (7.5YR 5/4) dry; weak medium and coarse subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few fine roots and common medium and coarse roots; common very fine tubular pores; few faint clay films on peds and in pores; 5 percent gravel; neutral (pH 7.0); clear wavy boundary.

3Btb3—39 to 58 inches; dark brown (7.5YR 3/4) clay loam, brown (7.5YR 5/4) dry; moderate coarse subangular blocky structure; slightly hard, friable, sticky and slightly plastic; few medium roots; common very fine and fine tubular pores; common faint clay films on peds and in pores; 5 percent gravel; neutral (pH 7.0); clear wavy boundary.

3Btb4—58 to 63 inches; dark brown (10YR 3/3) clay loam, brown (10YR 5/3) dry; weak fine subangular blocky structure; hard, firm, sticky and slightly plastic; many very fine and fine tubular and interstitial pores; common faint clay films on peds and in pores; 5 percent gravel; neutral (pH 7.0).

Depth to bedrock is more than 60 inches. Depth to the buried argillic horizon and thickness of the mantle of ash are 14 to 33 inches.

The O horizon is 1 to 3 inches thick except in areas that have been disturbed.

The A horizon has value of 2 or 3 when moist and 4 to 6 when dry, and it has chroma of 2 to 4 when moist or dry. It is 0 to 10 percent gravel and 0 to 10 percent cobbles. Total rock fragment content is 0 to 15 percent. The horizon is 5 to 15 percent clay.

A Bw horizon is in the mantle of ash in some pedons.

The 2Btb and 3Btb horizons have value of 3 or 4 when moist and 5 or 6 when dry, and they have chroma of 3 or 4 when moist and 3 to 6 when dry. The horizons are loam, clay loam, gravelly loam, or gravelly clay loam and are 18 to 35 percent clay. They are 5 to 20 percent gravel, 0 to 20 percent cobbles, and 0 to 5 percent stones. Total rock fragment content is 5 to 35 percent.

Statz Series

The Statz series consists of well drained soils that are shallow to a duripan. These soils are on lava plains. They formed in ash. Slopes are 0 to 30 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Statz sandy loam in an area of Statz-Deschutes complex, 0 to 15 percent slopes; about 2,700 feet west and 1,500 feet north of the southeast corner of sec. 3, T. 15 S., R. 12 E.

A1—0 to 4 inches; grayish brown (10YR 5/2) sandy loam, dark grayish brown (10YR 3/2) moist; weak very fine granular structure; loose, very friable, nonsticky and nonplastic; many very fine and fine roots; many very fine interstitial pores; 5 percent gravel; mildly alkaline (pH 7.6); clear smooth boundary.

A2—4 to 14 inches; grayish brown (10YR 5/2) sandy loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure parting to moderate very fine granular; slightly hard, friable, nonsticky and nonplastic; common very fine, fine, and medium roots; common very fine tubular and vesicular pores; 5 percent gravel; moderately alkaline (pH 7.8); abrupt wavy boundary.

2Bkq—14 to 20 inches; brown (10YR 5/3) sandy loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky structure; hard, firm, slightly sticky and slightly plastic; few very fine and fine roots; common very fine and fine tubular pores; 5 percent gravel; 10 percent durinodes; strongly effervescent; moderately alkaline (pH 8.0); abrupt smooth boundary.

2Bkqm—20 to 25 inches; indurated duripan; abrupt wavy boundary.

3R—25 inches; basalt.

Depth to bedrock is 20 to 40 inches. Depth to the indurated duripan is 10 to 20 inches.

The A horizon has chroma of 2 or 3 when moist or dry. It is 0 to 15 percent gravel. It is neutral or mildly alkaline.

The 2Bkq has value of 5 or 6 when dry and 3 or 4 when moist, and it has chroma of 3 or 4 when moist or dry. It is sandy loam or loam. The horizon is 0 to 15 percent gravel and 5 to 15 percent durinodes. It is mildly alkaline or moderately alkaline.

Steiger Series

The Steiger series consists of very deep, somewhat excessively drained soils on pumice-mantled lava plains and hills. These soils formed in ash and pumice over colluvium and old alluvium. Slopes are 0 to 50 percent. The mean annual precipitation is about 20 inches, and the mean annual air temperature is about 43 degrees F.

Typical pedon of Steiger loamy coarse sand, 0 to 15 percent slopes; about 1 mile east of U.S. Highway 97; in the SW1/4NW1/4 of sec. 20, T. 23 S., R. 10 E.

Oi—3 inches to 0; ponderosa pine litter.

A—0 to 2 inches; dark grayish brown (10YR 4/2) loamy coarse sand, grayish brown (10YR 5/2) dry; moderate fine granular structure; soft, very friable, nonsticky and nonplastic; many very fine and fine roots; many very fine interstitial pores; 10 percent pumiceous gravel; 50 percent pumice (0.5 to 2.0 millimeters); neutral (pH 6.8); clear irregular boundary.

AC—2 to 18 inches; dark brown (10YR 4/3) gravelly coarse sand, pale brown (10YR 6/3) dry; single grain; loose, nonsticky and nonplastic; many fine, medium, and coarse roots; many very fine interstitial pores; 25 percent pumiceous gravel; 60 percent pumice (0.5 to 2.0 millimeters); neutral (pH 6.8); clear wavy boundary.

C1—18 to 28 inches; light brownish gray (10YR 6/2) and very pale brown (10YR 8/3) very gravelly coarse sand, very pale brown (10YR 8/3) dry; single grain; loose, nonsticky and nonplastic; few fine, medium, and coarse roots; many very fine interstitial pores; 50 percent pumiceous gravel; 70 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.0); abrupt wavy boundary.

C2—28 to 49 inches; pale yellow (2.5Y 7/4) and white (2.5Y 8/2) gravelly coarse sand, pale yellow (2.5Y 7/4) and white (2.5Y 8/2) dry; single grain; loose, nonsticky and nonplastic; many fine and medium roots along krotovina; many very fine interstitial pores; common krotovinas (4 inches in diameter); thin subhorizons in lower part; 15 percent pumiceous gravel; 70 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.0); abrupt smooth boundary.

2Bwb—49 to 60 inches; dark yellowish brown (10YR 3/4) loam, brown (10YR 5/3) dry; common medium brown (7.5YR 5/4) mottles; weak medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; many fine roots; many very fine interstitial pores; 5 percent pumiceous gravel, 10 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.0).

Depth to bedrock is more than 60 inches. Depth to the 2Bwb horizon is 40 to 60 inches.

The A horizon has value of 3 or 4 when moist and 4 or 5 when dry, and it has chroma of 2 or 3 when moist or dry. It is 0 to 10 percent pumiceous gravel.

The AC horizon has hue of 10YR or 7.5YR, value of 3 or 4 when moist and 4 to 6 when dry, and chroma of 2 to 4 when moist or dry. It is 5 to 35 percent pumiceous gravel. The horizon is coarse sand or loamy coarse sand.

The C horizon has value of 6 to 8 when moist or dry and chroma of 2 to 4 when moist or dry. It has 15 to 60 percent pumiceous gravel. The horizon is coarse sand or loamy coarse sand.

The 2Bwb horizon has hue of 7.5YR or 10YR, value of 3 or 4 when moist and 5 or 6 when dry, and chroma of 3 or 4 when moist or dry. Some pedons are mottled. The horizon is loam or sandy loam and is 0 to 10 percent pumiceous gravel.

Stookmoor Series

The Stookmoor series consists of moderately deep, somewhat excessively drained soils on hills and lava plains. These soils formed in ash. Slopes are 1 to 50 percent. The mean annual precipitation is about 11 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Stookmoor loamy sand, 1 to 3 percent slopes; in the NW1/4SW1/4NW1/4 of sec. 11, T. 19 S., R. 15 E.

A—0 to 6 inches; grayish brown (10YR 5/2) loamy sand, very dark grayish brown (10YR 3/2) moist; weak thick platy structure; soft, very friable, nonsticky and nonplastic; many very fine and fine roots; many fine and medium irregular pores; about 50 percent ash; moderately alkaline; clear wavy boundary.

AB—6 to 14 inches; grayish brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) moist; massive; slightly hard, friable, nonsticky and nonplastic; many very fine and fine roots; many fine irregular pores; about 50 percent ash; moderately alkaline; abrupt wavy boundary.

Bq—14 to 24 inches; pale brown (10YR 6/3) sandy loam, dark brown (10YR 3/3) moist; massive; very hard, very firm and brittle; slightly sticky and slightly plastic; few very fine roots; common very fine discontinuous tubular pores; about 15 percent ash; moderately alkaline; abrupt wavy boundary.

2R—24 inches; basalt.

Depth to the brittle layer is 14 to 20 inches, and depth to bedrock is 20 to 40 inches. The profile is neutral to moderately alkaline.

The A horizon has value of 4 or 5 when dry and 2 or 3 when moist. It is loamy sand or gravelly loamy sand and is 0 to 25 percent gravel and 0 to 10 percent cobbles.

The AB horizon has chroma of 2 or 3 when moist or dry. It is loamy sand or sandy loam and is 0 to 25 percent gravel and 0 to 10 percent cobbles.

The 2Bq horizon has value of 6 or 7 when dry and 3 or 4 when moist, and it has chroma of 3 or 4 when moist or dry. It is sandy loam or loam and is 10 to 20 percent clay. It is 0 to 25 percent gravel and 0 to 10 percent cobbles.

Stukel Series

The Stukel series consists of shallow, well drained soils on lava plains. These soils formed in ash. Slopes are 0 to 15 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Stukel sandy loam in an area Deschutes-Stukel complex, dry, 0 to 8 percent slopes; about 0.75 mile north of Oregon Highway 26; in the NE1/4NE1/4 of sec. 14, T. 15 S., R. 13 E.

A1—0 to 4 inches; grayish brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) moist; weak thin and medium platy structure; slightly hard, friable, nonsticky and nonplastic; common very fine and fine roots; many very fine interstitial pores; 5 percent cobbles; mildly alkaline (pH 7.4); clear wavy boundary.

A2—4 to 11 inches; brown (10YR 5/3) cobbly sandy loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; common very fine, fine, medium, and coarse roots; many very fine interstitial pores and common very fine tubular pores; 5 percent gravel and 15 percent cobbles; mildly alkaline (pH 7.6); abrupt smooth boundary.

Bkq—11 to 18 inches; pale brown (10YR 6/3) gravelly sandy loam, dark brown (10YR 4/3) moist; moderate fine and medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; common fine roots; common very fine tubular pores; 10 percent durinodes; 15 percent gravel and 5 percent cobbles; slightly effervescent with carbonates as filaments and as coatings on rock fragments; mildly alkaline (pH 7.8); abrupt wavy boundary.

R—18 inches; basalt.

Depth to bedrock is 10 to 20 inches. The profile is 5 to 15 percent clay.

The A horizon has value of 4 or 5 when dry and 3 when moist, and it has chroma of 2 or 3 when moist or dry. The horizon is 0 to 5 percent gravel and 0 to 15 percent cobbles. It is neutral or mildly alkaline.

The Bkq horizon has value of 5 to 7 when dry and 4 or 5 when moist, and it has chroma of 3 or 4 when moist or dry. The horizon is sandy loam or gravelly sandy loam. It is 5 to 15 percent gravel, 0 to 5 percent cobbles, and 0 to 10 percent durinodes. It is neutral or mildly alkaline.

A thin, weakly cemented horizon is above the bedrock in some pedons.

The R horizon typically is basalt, but in some pedons it consists of other volcanic rock, including tuff.

Suilotem Series

The Suilotem series consists of very deep, somewhat poorly drained soils on outwash plains. These soils formed in ash over glacial outwash. Slopes are 0 to 8 percent. The mean annual precipitation is about 25 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Suilotem sandy loam in an area of Suilotem-Circle complex, 0 to 8 percent slopes; about 150 feet north of Forest Service Road 1216, northeast of intersection of Forest Service Roads 1216 and 1419; in the NE$^1/_4$ of sec. 9, T. 13 S., R. 9 E.

Oi—1 inch to 0; litter of ponderosa pine and western larch needles and mixed grasses.

A1—0 to 5 inches; dark brown (10YR 3/3) sandy loam, dark grayish brown (10YR 4/2) dry; moderate very fine granular structure; slightly hard, friable, nonsticky and slightly plastic; many very fine, fine, and medium roots; many fine irregular pores; 10 percent pumice (2 to 5 millimeters); neutral (pH 6.6); clear wavy boundary.

A2—5 to 16 inches; dark brown (10YR 3/3) sandy loam, yellowish brown (10YR 5/4) dry; moderate very fine granular structure; slightly hard, friable, nonsticky and nonplastic; common very fine, medium, and coarse roots; many fine irregular pores; 15 percent pumice (2 to 5 millimeters); neutral (pH 6.8); clear wavy boundary.

C1—16 to 27 inches; dark brown (10YR 3/3) sandy loam, yellowish brown (10YR 5/4) dry; massive; slightly hard, friable, nonsticky and nonplastic; few very fine, medium, and coarse roots; many very fine irregular pores; 10 percent pumice (2 to 5 millimeters); neutral (pH 6.8); clear irregular boundary.

2C2—27 to 30 inches; very dark brown (10YR 2/2) fine sandy loam, light gray (10YR 7/2) dry; massive; slightly hard, friable, nonsticky and nonplastic; few very fine, medium, and coarse roots; many very fine irregular pores; 10 percent pumice (2 to 5 millimeters); 5 percent rounded gravel; neutral (pH 7.0); abrupt broken boundary.

2C3—30 to 51 inches; black (10YR 2/1) loamy fine sand, dark gray (10YR 4/1) dry; common medium and large prominent strong brown (7.5YR 4/6) mottles; massive; slightly hard, friable, nonsticky and nonplastic; few very fine and medium roots; common fine tubular pores; 10 percent rounded gravel; neutral (pH 7.0); abrupt irregular boundary.

3Bwb—51 to 60 inches; dark brown (7.5YR 3/2) very fine sandy loam, pale brown (10YR 6/3) dry; common medium distinct brown (7.5YR 4/4) mottles; strong fine and medium subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; common medium and coarse roots; common fine tubular pores; common medium iron concretions; 5 percent rounded gravel; neutral (pH 7.0).

Depth to glacial outwash material (3Bwb horizon) is 40 to 60 inches. Depth to bedrock is more than 60 inches. Depth to mottles is 30 to 40 inches.

The O horizon is 1 to 3 inches thick except in areas that have been disturbed.

The A and C horizons have hue of 10YR when moist or dry, value of 2 or 3 when moist and 4 or 5 when dry, and chroma of 2 or 3 when moist and 2 to 4 when dry. They are 5 to 15 percent pumice gravel. They are slightly acid or neutral.

The 2C horizon has hue of 10YR, value of 2 or 3 when moist and 4 to 7 when dry, and chroma of 1 to 3 when moist and 1 to 4 when dry. The horizon is fine sandy loam, loamy fine sand, or sandy loam. It is 5 to 15 percent gravel. It has common or many prominent mottles.

The 3B horizon has hue of 7.5YR or 10YR when moist or dry, value of 2 or 3 when moist and 5 or 6 when dry, and chroma of 2 when moist and 3 or 4 when dry. The horizon is very fine sandy loam or sandy loam. It is 5 to 10 percent gravel and 0 to 5 percent cobbles. Total rock fragment content is 5 to 10 percent. The horizon has common or many distinct or prominent mottles.

Sunriver Series

The Sunriver series consists of very deep, somewhat poorly drained soils on stream terraces. These soils formed in ash over old alluvium. Slopes are 0 to 3 percent. The mean annual precipitation is about 20 inches, and the mean annual air temperature is about 42 degrees F.

Typical pedon of Sunriver sandy loam, 0 to 3 percent slopes; 1,500 feet west and 1,500 feet north of the southeast corner of sec. 1, T. 21 S., R. 10 E.

Oi—2 inches to 0; litter of lodgepole pine needles and twigs.

A—0 to 5 inches; very dark gray (10YR 3/1) sandy loam, light gray (10YR 6/1) dry; weak fine granular structure; slightly hard, friable, nonsticky and nonplastic; few very fine roots and common medium roots; common very fine interstitial pores; 70 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.0); abrupt wavy boundary.

AC—5 to 20 inches; dark gray (10YR 4/1) loamy coarse sand, light gray (10YR 7/1) dry; single grain; soft, very friable, nonsticky and nonplastic; few very fine and fine roots; many very fine interstitial pores; 70 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.2); clear smooth boundary.

C1—20 to 24 inches; light brownish gray (10YR 6/2) coarse sand, light gray (10YR 7/2) dry; few fine faint very dark grayish brown (10YR 3/2) mottles; single grain; loose, nonsticky and nonplastic; common very fine interstitial pores; 80 percent pumice (0.5 to 2.0 millimeters); few krotovinas (10 centimeters in diameter); neutral (pH 7.2); abrupt smooth boundary.

C2—24 to 29 inches; light brownish gray (10YR 6/2) coarse sand, very pale brown (10YR 7/3) dry; common medium distinct dark yellowish brown (10YR 3/4), light olive brown (2.5Y 5/6), and dark reddish brown (5YR 3/4) mottles; single grain; loose, nonsticky and nonplastic; common very fine interstitial pores; 80 percent pumice (0.5 to 2.0 millimeters); few krotovinas (10 centimeters in diameter); alternating bands of dark yellowish brown (10YR 3/4) and light brownish gray (10YR 6/2) stains throughout; neutral (pH 7.2); abrupt smooth boundary.

2Bwb—29 to 60 inches; very dark gray (10YR 3/1) sandy loam, pale brown (10YR 6/3) dry; many medium distinct dark reddish brown (5YR 3/4) and dark brown (7.5YR 3/4) mottles; massive; slightly hard, friable, nonsticky and nonplastic; many very fine tubular pores; mildly alkaline (pH 7.4).

Depth to the loamy buried soil is 25 to 35 inches, and depth to bedrock is more than 60 inches. Depth to mottles is 20 to 30 inches.

The A horizon has hue of 10YR, value of 2 or 3 when moist and 4 to 6 when dry, and chroma of 1 or 2 when moist or dry.

The AC horizon has hue of 10YR, value of 3 or 4 when moist and 5 to 7 when dry, and chroma of 1 or 2 when moist or dry. The horizon is coarse sand or loamy coarse sand. It is 50 to 80 percent pumice (0.5 to 2.0 millimeters).

The C horizon has hue of 10YR, value of 3 to 7 when moist and 6 or 7 when dry, and chroma of 2 to 4 when moist or dry. The horizon is 50 to 80 percent pumice (0.5 to 2.0 millimeters).

The 2B horizon has hue of 10YR, value of 3 or 4 when moist and 5 or 6 when dry, and chroma of 1 to 4 when moist or dry. The horizon is sandy loam or fine sandy loam. It is neutral or mildly alkaline.

Suttle Series

The Suttle series consists of very deep, somewhat poorly drained soils on outwash plains. These soils formed in ash and scoria over glacial outwash. Slopes are 0 to 15 percent. The mean annual precipitation is about 30 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Suttle very gravelly loamy sand, 0 to 15 percent slopes; 60 feet north of Forest Service Road 12 and 12 miles up the road; in the SW1/4SW1/4 of sec. 8, T. 13 S., R. 9 E.

Oi—1 inch to 0; Douglas fir needles and twigs and ponderosa pine and white fir needles.

A1—0 to 3 inches; black (10YR 2/1) very gravelly loamy sand, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure parting to weak fine granular; soft, very friable, nonsticky and nonplastic; common medium roots and many very fine and fine roots; many very fine interstitial pores; 40 percent angular gravel-sized cinders; slightly acid (pH 6.4); clear smooth boundary.

A2—3 to 10 inches; black (10YR 2/1) very gravelly loamy sand, dark yellowish brown (10YR 4/4) dry; weak fine subangular blocky structure parting to weak fine granular; soft, very friable, nonsticky and nonplastic; common very fine roots; many very fine interstitial pores; 35 percent angular gravel-sized cinders; neutral (pH 6.8); abrupt smooth boundary.

2C1—10 to 22 inches; mixed black (10YR 2/1) and dark brown (10YR 3/3) very gravelly coarse sand, dark gray (10YR 4/1) and yellowish brown (10YR 5/4) dry; single grain; loose; nonsticky and nonplastic; few very fine, fine, and medium roots; many very fine interstitial pores; 50 percent angular gravel-sized cinders; neutral (pH 7.0); abrupt smooth boundary.

3C2—22 to 29 inches; dark brown (10YR 3/3) gravelly sandy loam, dark yellowish brown (10YR 4/4) dry; massive; slightly hard, friable, nonsticky and nonplastic; few very fine, fine, and medium roots; few very fine tubular pores; 20 percent subrounded gravel; neutral (pH 7.0); clear irregular boundary.

4C3—29 to 37 inches; black (10YR 2/1) loamy fine sand, very dark grayish brown (10YR 3/2) dry; single grain; soft, very friable, nonsticky and nonplastic; few very fine, fine, and medium roots; few very fine tubular pores; neutral (pH 7.0); gradual wavy boundary.

5C4—37 to 49 inches; dark brown (10YR 3/3) sandy loam, yellowish brown (10YR 5/4) dry; massive; slightly hard, friable, nonsticky and nonplastic; few very fine, fine, and medium roots; few very fine tubular pores; neutral (pH 7.0); gradual wavy boundary.

5C5—49 to 60 inches; dark brown (10YR 3/3) sandy loam, yellowish brown (10YR 5/4) dry; massive; slightly hard, friable, nonsticky and nonplastic; few very fine, fine, and medium roots; few very fine tubular pores; neutral (pH 7.0).

Depth to bedrock is more than 60 inches. Depth to the stratified glacial outwash (3C horizon) is 20 to 30 inches. The profile is slightly acid or neutral.

The O horizon is 1 to 3 inches thick except in areas that have been disturbed.

The A horizon has hue of 10YR when moist or dry, value of 2 or 3 when moist and 4 when dry, and chroma of 1 when moist and 2 to 4 when dry. It is 5 to 15 percent clay and 35 to 50 percent angular gravel-sized cinders.

The 2C horizon has hue of 10YR when moist or dry, value of 2 or 3 when moist and 4 or 5 when dry, and chroma of 1 to 3 when moist and 1 to 4 when dry. The horizon is 0 to 5 percent clay and 40 to 70 percent angular scoriaceous gravel-sized cinders. It is very gravelly coarse sand or extremely gravelly coarse sand.

The underlying C horizons are stratified gravelly sandy loam, loamy fine sand, and sandy loam. They have hue of 10YR when moist or dry, value of 2 or 3 when moist and 3 to 5 when dry, and chroma of 1 to 3 when moist and 2 to 4 when dry. The horizons are 5 to 15 percent clay and 0 to 30 percent subrounded gravel.

Swaler Series

The Swaler series consists of very deep, moderately well drained soils on old lake terraces. These soils formed in lacustrine sediment. Slopes are 0 to 2 percent. The mean annual precipitation is about 11 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Swaler silt loam, 0 to 2 percent slopes; 40 feet south of trail; in the SE$^1/_4$SE$^1/_4$NW$^1/_4$ of sec. 24, T. 22 S., R. 20 E.

A1—0 to 3 inches; light gray (10YR 7/2) and light brownish gray (10YR 6/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak thick platy structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine and fine roots; many fine and medium vesicular pores; neutral (pH 6.6); abrupt smooth boundary.

A2—3 to 7 inches; light brownish gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) moist; weak thin platy structure parting to weak very fine granular; slightly hard, friable, slightly sticky and nonplastic; common very fine and fine roots; many very fine irregular pores; neutral (pH 6.6); abrupt wavy boundary.

2A3—7 to 10 inches; light gray (10YR 7/1) silt loam, gray (10YR 5/1) moist; weak thin platy structure; hard, friable, slightly sticky and nonplastic; few very fine roots; common very fine tubular pores; neutral (pH 6.8); abrupt wavy boundary.

3Bt1—10 to 14 inches; brown (10YR 5/3) and light gray (10YR 7/1) clay, brown (10YR 3/3) moist; moderate medium and fine prismatic structure parting to moderate fine angular blocky; very hard, very firm, very sticky and very plastic; few very fine roots; many very fine tubular pores; common distinct clay films on peds and few faint clay films in pores; about 40 percent light gray uncoated sand and silt grains on peds; few tongues of 2A horizon material; mildly alkaline (pH 7.6); clear wavy boundary.

3Bt2—14 to 26 inches; pale brown (10YR 6/3) and brown (10YR 5/3) silty clay loam, dark brown (10YR 3/3) moist, dark brown (10YR 4/3) moist and crushed; weak thin platy structure parting to strong very fine angular blocky; hard, firm, very sticky and plastic; few very fine roots; common very fine tubular pores; common distinct clay films on peds and faint clay films in pores; mildly alkaline (pH 7.6); clear wavy boundary.

3C—26 to 60 inches; pale brown (10YR 6/4) silty clay loam, dark brown (10YR 4/3) moist; weak thin platy structure; hard, firm, sticky and plastic; few very fine roots; few very fine tubular pores; few thin cutans on faces of peds; mildly alkaline (pH 7.6).

Depth to bedrock is more than 60 inches. A clay increase of 15 to 25 percent is between the 2A and 3Bt horizons. Some pedons have carbonates below a depth of 40 inches. The particle-size control section is 35 to 50 percent clay.

The A horizon has chroma of 1 or 2 when moist or dry. It is silt loam or gravelly coarse sand. The gravelly coarse sand is about 60 percent pumiceous ash and is as much as 7 inches thick.

The 2A horizon has value of 7 or 8 when dry and 4 or 5 when moist, and it has chroma of 1 or 2 when moist or dry. The horizon is a deposit of ash from Newberry Crater.

The 3Bt horizon has value of 3 to 5 when moist, and it has chroma of 2 to 4 when moist or dry. The upper part of the horizon commonly has uncoated sand and silt grains and tongues of 2A horizon material.

Structure is prismatic or columnar. The horizon is silty clay loam, silty clay, or clay and is 0 to 5 percent gravel. It is neutral to moderately alkaline.

The 3C horizon is silty clay loam or clay loam.

Swalesilver Series

The Swalesilver series consists of very deep, somewhat poorly drained soils in closed basins on lava plains. These soils formed in lacustrine sediment. Slopes are 0 to 1 percent. The mean annual precipitation is about 11 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Swalesilver loam, 0 to 1 percent slopes; 200 feet east and 1,800 feet south of the northwest corner of sec. 31, T. 22 S., R. 19 E.

A1—0 to 3 inches; light gray (10YR 7/2) loam, grayish brown (10YR 5/2) moist; few fine distinct yellowish red (5YR 4/6) mottles; weak medium platy structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine roots; common fine vesicular pores; slightly acid (pH 6.2); abrupt smooth boundary.

2A2—3 to 5 inches; light gray (10YR 7/1) silt loam, gray (10YR 5/1) moist; moderate medium platy structure; slightly hard, friable, slightly sticky and slightly plastic; common fine roots; common fine tubular pores; neutral (pH 7.2); abrupt smooth boundary.

3Bt1—5 to 13 inches; light brownish gray (10YR 6/2) clay, dark grayish brown (10YR 4/2) moist; strong fine angular blocky structure; hard, very firm, sticky and plastic; common fine and medium roots; few fine tubular pores; few thin clay films in pores; many stress surfaces; mildly alkaline (pH 7.5); clear smooth boundary.

3Bt2—13 to 18 inches; light brownish gray (10YR 6/2) clay, dark grayish brown (10YR 4/2) moist; moderate fine angular blocky structure; hard, very firm, very sticky and very plastic; common fine and medium roots; common fine tubular pores; few faint clay films in pores; moderately alkaline (pH 7.8); clear wavy boundary.

3BCk1—18 to 40 inches; grayish brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) moist; massive; hard, very firm, slightly sticky and slightly plastic; few fine roots, few fine tubular pores; strongly effervescent; strongly alkaline (pH 8.6); gradual smooth boundary.

3BCk2—40 to 50 inches; pale brown (10YR 6/3) clay loam, dark brown (10YR 4/3) moist; massive; hard, very firm, slightly sticky and plastic; few fine tubular pores; strongly effervescent; 2 percent seams of light gray lime; strongly alkaline (pH 8.6); clear smooth boundary.

4C—50 to 60 inches; light olive brown (2.5YR 5/4) loam, olive brown (2.5Y 4/4) moist; massive with thin horizontal bedding planes; hard, very firm, slightly sticky and slightly plastic; few fine tubular pores; moderately alkaline (pH 8.0).

Depth to bedrock is more than 60 inches. The particle-size control section is 45 to 60 percent clay.

The A horizon has value of 4 or 5 when moist and 6 or 7 when dry, and it has chroma of 2 when moist or dry. It is slightly acid to mildly alkaline.

The 2A horizon has value of 5 or 6 when moist and 7 or 8 when dry, and it has chroma of 1 or 2 when moist or dry. It is neutral or mildly alkaline.

The 3Bt horizon has value of 3 or 4 when moist and 5 or 6 when dry, and it has chroma of 2 or 3 when moist or dry. The horizon is clay or silty clay and is 45 to 65 percent clay.

The 3BCk horizon has hue of 10YR or 2.5Y when moist or dry, value of 4 or 5 when moist and 5 or 6 when dry, and chroma of 2 or 3 when moist or dry. The horizon is silty clay loam or clay loam and is 30 to 35 percent clay. The upper part of the horizon has disseminated lime, and the lower part has soft concretions of lime. The horizon is mildly alkaline to strongly alkaline.

The 4C horizon has hue of 2.5Y or 5Y when moist or dry, value of 4 or 5 when moist and 5 or 6 when dry, and chroma of 2 to 4 when moist. It is stratified loam, silt loam, and clay loam and is 15 to 30 percent clay. The horizon is noncalcareous or slightly calcareous. It is mildly alkaline to strongly alkaline.

Tetherow Series

The Tetherow series consists of excessively drained soils that are shallow or moderately deep to cinders. These soils are on lava plains. They formed in ash over cinders. Slopes are 0 to 50 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 49 degrees F.

Typical pedon of Tetherow sandy loam, 0 to 3 percent slopes; 0.5 mile northwest of Terrebonne, adjacent to cinder pit; 1,200 feet south and 300 feet east of the northwest corner of sec. 16, T. 14 S., R. 13 E.

Ap—0 to 6 inches; brown (10YR 5/3) sandy loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; slightly hard, friable, nonsticky and nonplastic; common very fine roots; many very fine irregular pores; mildly alkaline (pH 7.4); clear smooth boundary.

A—6 to 19 inches; brown (10YR 5/3) sandy loam, very dark grayish brown (10YR 3/2) moist; weak medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; common very fine and fine roots; common very fine and few fine irregular pores; 5 percent gravel; mildly alkaline (pH 7.6); clear wavy boundary.

AC—19 to 24 inches; pale brown (10YR 6/3) cobbly sandy loam, very dark grayish brown (10YR 3/2) moist; weak medium subangular blocky structure; slightly hard, firm, nonsticky and nonplastic; common very fine roots; many very fine irregular pores; few medium subangular concretions; 20 percent cobbles; mildly alkaline (pH 7.4); clear wavy boundary.

2C—24 to 60 inches; cinders that are dark reddish brown (5YR 3/4) moist or dry; single grain.

Depth to bedrock is more than 60 inches. Thickness of the solum and depth to cinders are 14 to 28 inches. The profile is neutral or mildly alkaline.

The A horizon has hue of 10YR, value of 2 or 3 when moist and 5 when dry, and chroma of 2 or 3 when moist or dry. It is 0 to 10 percent gravel.

The AC horizon has chroma of 2 or 3 when moist or dry. It is 0 to 25 percent cobbles and 0 to 10 percent gravel. It is sandy loam or cobbly sandy loam.

The 2C horizon has hue of 10YR or 5YR, value of 3 when moist and 5 or 6 when dry, and chroma of 3 when moist and 3 or 4 when dry. It is 90 to 100 percent cinders (more than 2.0 millimeters). Thin, brittle, discontinuous layers are in some pedons.

Thorn Series

The Thorn series consists of shallow, well drained soils on mountains. These soils formed in ash over colluvium and residuum. Slopes are 15 to 50 percent. The mean annual precipitation is about 20 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Thorn gravelly sandy loam in an area of Parrego-Thorn-Rock outcrop complex, 15 to 50 percent slopes; on Forest Service Road 1160, 0.5 mile west of the junction with Forest Service Road 1160-410; in the NE1/4 of sec. 8, T. 12 S., R. 10 E.

Oi—1 inch to 0; ponderosa pine litter and grasses.

A1—0 to 4 inches; dark brown (10YR 3/3) gravelly sandy loam, grayish brown (10YR 5/2) dry; weak medium granular structure; slightly hard, friable, nonsticky and nonplastic; many very fine, fine, and medium roots; many fine interstitial pores; 15 percent gravel and 5 percent cobbles; 10 percent clay; neutral (pH 7.0); clear wavy boundary.

2A2—4 to 8 inches; dark brown (10YR 4/3) loam; light brownish gray (10YR 6/2) dry; weak medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; common very fine, fine, and medium roots; many very fine tubular pores; 12 percent clay; neutral (pH 7.0); clear wavy boundary.

2Btb—8 to 16 inches; dark brown (7.5YR 4/4) extremely cobbly loam, light brown (7.5YR 6/4) dry; moderate medium subangular blocky structure; hard, firm, nonsticky and slightly plastic; few coarse roots; common very fine tubular pores; common distinct clay films on peds and rock fragments; 15 percent gravel, 60 percent cobbles, and 20 percent stones; 20 percent clay; neutral (pH 7.2); clear wavy boundary.

2R—16 inches; andesite.

Depth to bedrock is 10 to 20 inches. The profile has hue of 10YR or 7.5YR.

The O horizon is 1 to 3 inches thick except in areas that have been disturbed.

The A horizon has value of 2 or 3 when moist and 5 or 6 when dry, and it has chroma of 3 when moist and 2 to 4 when dry. The horizon is 5 to 18 percent clay. It is 10 to 25 percent subrounded gravel and 0 to 10 percent subrounded to angular cobbles. Total rock fragment content is 15 to 30 percent.

The 2Btb horizon has chroma of 2 to 4 when moist or dry. It is very cobbly loam, extremely cobbly loam, or extremely stony loam and is 20 to 27 percent clay. The horizon is 10 to 25 percent angular gravel, 20 to 50 percent angular cobbles, and 10 to 40 percent stones. Total rock fragment content is 55 to 80 percent.

A 2Cr horizon is in some pedons. It is 1 to 3 inches thick.

Tub Series

The Tub series consists of deep, well drained soils on north-facing slopes of hills and canyons. These soils formed in loess over colluvium. Slopes are 15 to 60 percent. The mean annual precipitation is about 12 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Tub loam in an area of Schrier-Tub complex, 30 to 60 percent north slopes; in the NW1/4SW1/4NE1/4 of sec. 31, T. 12 S., R. 13 E.

A1—0 to 2 inches; dark grayish brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; slightly hard, friable, nonsticky and slightly plastic; many very fine and fine roots; many very fine interstitial pores; neutral (pH 7.2); clear wavy boundary.

A2—2 to 8 inches; dark grayish brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; weak fine subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; common very fine and fine roots; many very fine interstitial pores; neutral (pH 7.2); gradual wavy boundary.

A3—8 to 14 inches; dark grayish brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; weak fine subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; common fine and medium roots; many very fine interstitial pores; neutral (pH 7.2); gradual wavy boundary.

Bw—14 to 24 inches; brown (10YR 5/3) clay loam, dark brown (10YR 3/3) moist; weak fine subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; common fine and medium roots; many very fine interstitial pores; 10 percent gravel; neutral (pH 7.2); clear wavy boundary.

2Bt—24 to 28 inches; brown (10YR 5/3) very cobbly clay, dark brown (10YR 3/3) moist; moderate fine and medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few fine, medium, and coarse roots; common fine interstitial pores and few fine tubular pores; common faint clay films on faces of peds and in pores; 25 percent gravel and 15 percent cobbles; mildly alkaline (pH 7.4); gradual wavy boundary.

2Btk—28 to 41 inches; brown (10YR 5/3) cobbly clay, dark brown (10YR 3/3) moist; moderate fine and medium subangular blocky structure; very hard, firm, slightly sticky and plastic; few fine, medium, and coarse roots; common fine interstitial pores and few fine tubular pores; many prominent clay films on faces of peds and in pores; 15 percent gravel and 15 percent cobbles; strongly effervescent with disseminated carbonates and coatings of carbonates on rock fragments; mildly alkaline (pH 7.6); clear irregular boundary.

2R—41 inches; rhyolite.

Depth to bedrock is 40 to 60 inches. Depth to secondary carbonates is 20 to 30 inches. The mollic epipedon is 20 to 25 inches thick. The particle-size control section averages 15 to 35 percent rock fragments.

The A horizon has value of 4 or 5 when dry. It is 20 to 27 percent clay.

The 2Bt horizon has value of 3 or 4 when moist, and it has chroma of 2 or 3 when moist or dry. The horizon is very cobbly clay or cobbly clay and is 40 to 60 percent clay.

The 2Btk horizon has value of 3 to 5 when moist and 5 to 7 when dry, and it has chroma of 3 when moist or dry. The horizon is cobbly clay or cobbly clay loam and is 30 to 50 percent clay. It is mildly alkaline or moderately alkaline.

Tumalo Series

The Tumalo series consists of well drained soils that are moderately deep to a duripan. These soils are on outwash plains. They formed in ash over glacial outwash. Slopes are 0 to 8 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 48 degrees F.

Typical pedon of Tumalo sandy loam, 0 to 3 percent slopes; 1,600 feet north and 900 feet east of the southwest corner of sec. 30, T. 16 S., R. 12 E.

A1—0 to 3 inches; dark grayish brown (10YR 4/2) sandy loam, very dark brown (10YR 2/2) moist; weak fine granular structure; slightly hard, friable, nonsticky and nonplastic; many very fine and fine roots; many very fine and fine interstitial pores; 10 percent gravel; neutral (pH 7.0); clear smooth boundary.

A2—3 to 10 inches; grayish brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) moist; weak fine and medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; common very fine and fine roots; common very fine and fine interstitial pores; 10 percent gravel; neutral (pH 7.2); clear smooth boundary.

AB—10 to 18 inches; grayish brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) moist; moderate fine and medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; common very fine and fine roots; common very fine and fine interstitial pores; 10 percent gravel; mildly alkaline (pH 7.4); abrupt smooth boundary.

Bw—18 to 32 inches; pale brown (10YR 6/3) very gravelly sandy loam, dark brown (10YR 3/3) moist; moderate medium and coarse subangular blocky structure; hard, friable, nonsticky and nonplastic; common very fine and fine roots and few medium roots; common very fine and fine interstitial pores; 35 percent gravel; mildly alkaline (pH 7.4); abrupt wavy boundary.

2Bkqm—32 to 44 inches; very pale brown (10YR 7/4) duripan; strongly cemented gravel with indurated laminar capping on surface and in fractures; strongly effervescent; moderately alkaline (pH 8.4); abrupt wavy boundary.

3C—44 to 90 inches; black (10YR 2/1) and very pale brown (10YR 7/3) extremely gravelly sand, black

(10YR 2/1) and pale brown (10YR 6/3) moist; single grain; loose, nonsticky and nonplastic; 70 percent gravel; neutral (pH 7.2).

Depth to the indurated duripan is 20 to 40 inches. Depth to bedrock is more than 60 inches. The solum is 20 to 60 percent pumice (0.5 to 2.0 millimeters). It is 5 to 10 percent clay and 55 to 75 percent sand.

The A horizon has value of 4 or 5 when dry and 2 or 3 when moist, and it has chroma of 1 or 2 when moist or dry. It is 0 to 10 percent gravel and 0 to 15 percent cobbles and stones. Total rock fragment content is 0 to 15 percent.

The Bw horizon has value of 5 or 6 when dry and 3 or 4 when moist, and it has chroma of 2 or 3 when moist or dry. The horizon is gravelly or very gravelly sandy loam and is 15 to 40 percent gravel. It is neutral or mildly alkaline.

The 3C horizon is extremely gravelly or very gravelly sand and is 35 to 70 percent gravel. It is neutral or mildly alkaline.

Tutni Series

The Tutni series consists of very deep, somewhat poorly drained soils on pumice-mantled stream terraces. These soils formed in ash and pumice over colluvium and old alluvium. Slopes are 0 to 3 percent. The mean annual precipitation is about 20 inches, and the mean annual air temperature is about 42 degrees F.

Typical pedon of Tutni loamy coarse sand, 0 to 3 percent slopes; 200 feet west and 300 feet south of the northeast corner of sec. 32, T. 22 S., R. 10 E.

Oi—1 inch to 0; litter of lodgepole pine needles.

A—0 to 4 inches; very dark grayish brown (10YR 3/2) loamy coarse sand, pale brown (10YR 6/3) dry; weak very fine granular structure; soft, very friable, nonsticky and nonplastic; many very fine and fine roots; many very fine interstitial pores; 10 percent pumice gravel; slightly acid (pH 6.4); clear smooth boundary.

AC—4 to 10 inches; dark brown (10YR 3/3) loamy coarse sand, pale brown (10YR 6/3) dry; single grain; soft, very friable, nonsticky and nonplastic; few very fine, fine, and medium roots; many very fine interstitial pores; 10 percent pumice gravel; neutral (pH 6.8); gradual wavy boundary.

C1—10 to 24 inches; dark grayish brown (10YR 4/2) very gravelly coarse sand, light yellowish brown (10YR 6/4) dry; few faint brown (7.5YR 5/4) mottles; single grain; soft, loose, nonsticky and nonplastic; few very fine roots; many very fine interstitial pores; 40 percent pumice gravel; neutral (pH 7.2); gradual wavy boundary.

C2—24 to 43 inches; dark grayish brown (10YR 4/2) very gravelly coarse sand, light yellowish brown (10YR 6/4) dry; many faint very dark grayish brown (10YR 3/2) mottles; single grain; soft, loose, nonsticky and nonplastic; few very fine roots; many very fine interstitial pores; 40 percent pumice gravel; neutral (pH 7.2); clear smooth boundary.

2Bwb—43 to 60 inches; very dark grayish brown (10YR 3/2) sandy loam, brown (10YR 5/3) dry; weak medium subangular blocky structure; soft, very friable, nonsticky and nonplastic; many very fine interstitial pores; 10 percent gravel; neutral (pH 7.2).

Depth to bedrock is more than 60 inches. Depth to the 2Bwb horizon is 40 to 60 inches. A water table is at a depth of 18 to 48 inches in April through June.

The A horizon has hue of 10YR or 7.5YR when moist or dry, value of 2 or 3 when moist and 4 to 6 when dry, and chroma of 2 or 3 when moist or dry. It is 0 to 10 percent pumice gravel.

The AC horizon has hue of 10YR or 7.5YR when moist or dry, value of 2 to 4 when moist and 4 to 6 when dry, and chroma of 2 or 3 when moist or dry. It is 0 to 10 percent pumice gravel.

The C horizon has hue of 5YR to 2.5Y, value of 3 to 6 when moist and 5 to 7 when dry, and chroma of 2 to 6 when moist and 2 to 4 when dry. The horizon is 20 to 50 percent pumice gravel. It is loamy coarse sand or coarse sand.

The 2Bwb horizon has chroma of 2 or 3 when moist or dry. It is 0 to 10 percent gravel. The horizon is loam, fine sandy loam, or sandy loam and is 10 to 20 percent clay.

Vergas Series

The Vergas series consists of very deep, well drained soils on lake terraces. These soils formed in old alluvium. Slopes are 0 to 3 percent. The mean annual precipitation is about 11 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Vergas loam, 0 to 3 percent slopes; about 1,100 feet north and 1,500 feet east of the southwest corner of sec. 13, T. 22 S., R. 22 E.

A—0 to 3 inches; light brownish gray (10YR 6/2) loam, very dark grayish brown (10YR 3/2) moist; weak thin platy structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; many fine vesicular pores; about 10 percent gravel; neutral (pH 7.0); clear wavy boundary.

AB—3 to 5 inches; light brownish gray (10YR 6/2) loam, very dark grayish brown (10YR 3/2) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; many very fine irregular pores; about 10 percent gravel; neutral (pH 7.0); clear wavy boundary.

BA—5 to 10 inches; grayish brown (10YR 5/2) loam, dark brown (10YR 3/3) moist; weak fine subangular blocky structure; slightly hard, friable, sticky and slightly plastic; many fine roots and few medium roots; common very fine tubular pores; about 10 percent gravel; neutral (pH 7.0); gradual wavy boundary.

Bt—10 to 25 inches; pale brown (10YR 6/3) clay loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky structure; hard, friable, sticky and plastic; few fine roots; few very fine tubular pores; about 10 percent gravel; few faint clay films on peds and in pores; mildly alkaline (pH 7.6); clear wavy boundary.

BC—25 to 29 inches; pale brown (10YR 6/3) gravelly loam, dark brown (10YR 4/3) moist; moderate medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few fine roots; common very fine tubular pores; about 20 percent gravel; mildly alkaline (pH 7.8); clear smooth boundary.

2Bq—29 to 60 inches; pale brown (10YR 6/3) extremely gravelly loamy sand, dark brown (10YR 4/3) moist; massive; hard, firm and brittle, nonsticky and nonplastic; few very fine roots; many very fine irregular pores; about 60 percent gravel; mildly alkaline (pH 7.8).

Depth to the brittle layer is 20 to 40 inches. Depth to bedrock is more than 60 inches. The profile is neutral or mildly alkaline.

The A horizon has value of 5 or 6 when dry. It is 5 to 15 percent gravel.

The Bt horizon has value of 5 or 6 when dry and 3 or 4 when moist, and it has chroma of 3 or 4 when moist or dry. The horizon is 20 to 30 percent clay and 5 to 35 percent gravel. It is loam, clay loam, or gravelly loam.

The 2Bq horizon is 50 to 80 percent gravel. It is firm or very firm and is brittle. The horizon is very gravelly or extremely gravelly loamy sand.

Wanoga Series

The Wanoga series consists of moderately deep, well drained soils on hills. These soils formed in ash. Slopes are 0 to 50 percent. The mean annual precipitation is about 15 inches, and the mean annual air temperature is about 45 degrees F.

Typical pedon of Wanoga sandy loam, 15 to 30 percent slopes; 500 feet east and 500 feet south of the northwest corner of sec. 19, T. 14 S., R. 11 E.

Oi—1 inch to 0; litter of ponderosa pine needles and twigs.

A1—0 to 2 inches; very dark brown (10YR 2/2) sandy loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure; slightly hard, friable, nonsticky and nonplastic; common very fine and fine roots; many fine interstitial pores; 5 percent gravel; neutral (pH 6.8); gradual wavy boundary.

A2—2 to 12 inches; dark brown (10YR 3/3) sandy loam, brown (10YR 4/3) dry; weak fine and medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few very fine, fine, and medium roots; many very fine interstitial pores; 5 percent gravel; neutral (pH 6.8); gradual wavy boundary.

Bw—12 to 24 inches; dark brown (10YR 3/3) sandy loam, brown (10YR 5/3) dry; weak fine and medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few very fine, fine, medium, and coarse roots; many very fine interstitial pores and few fine tubular pores; 10 percent gravel; neutral (pH 7.0); clear wavy boundary.

2Crqt—24 to 34 inches; weathered tuff; coatings of silica and clay in vesicles; clear wavy boundary.

2R—34 inches; tuff.

Depth to bedrock is 20 to 40 inches.

The A horizon has hue of 10YR, value of 2 or 3 when moist and 4 or 5 when dry, and chroma of 2 or 3 when moist and 3 when dry. It is 0 to 10 percent gravel.

The Bw horizon has hue of 10YR, value of 3 or 4 when moist and 5 or 6 when dry, and chroma of 2 or 3 when moist or dry. It is sandy loam, fine sandy loam, or cobbly sandy loam. It is 0 to 10 percent durinodes and 0 to 25 percent concretions that are very friable when moist. The horizon is 5 to 15 percent gravel and 0 to 15 percent cobbles. Total coarse fragment content is 10 to 30 percent.

The 2Cr horizon has coatings of silica and clay. It has a discontinuous silica cap at the upper boundary in some pedons.

Westbutte Series

The Westbutte series consists of moderately deep, well drained soils on hills and mountains. These soils formed in colluvium derived from basalt or welded tuff with ash in the upper part. Slopes are 5 to 50 percent. The mean annual precipitation is about 13 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Westbutte stony loam in an area of Stookmoor-Westbutte complex, 25 to 50 percent north slopes; about 6.25 miles north from U.S. Highway 20, on the road that follows Lizard Creek; in roadcut on southeast side; in the NE1/4SE1/4NW1/4 of sec. 12, T. 21 S., R. 20 E.

A1—0 to 9 inches; very dark grayish brown (10YR 3/2) stony loam, very dark gray (10YR 3/1) moist; moderate very fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; many fine irregular pores; 5 percent gravel, 10 percent cobbles, and 5 percent stones; neutral (pH 6.8); clear wavy boundary.

A2—9 to 21 inches; dark brown (10YR 3/3) very cobbly loam, very dark grayish brown (10YR 3/2) moist; moderate fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; many fine interstitial pores; 5 percent gravel, 35 percent cobbles, and 10 percent stones; neutral (pH 6.8); clear wavy boundary.

Bw—21 to 30 inches; brown (10YR 5/3) very cobbly clay loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky structure; hard, firm, sticky and plastic; common very fine and fine roots; common very fine tubular pores; 5 percent gravel, 40 percent cobbles, and 10 percent stones; neutral (pH 6.9); abrupt wavy boundary.

R—30 inches; fractured, welded tuff.

Depth to bedrock is 20 to 40 inches. The profile is neutral or mildly alkaline.

The A horizon has value of 2 or 3 when moist and 3 to 5 when dry, and it has chroma of 1 or 2 when moist or dry. The fine earth fraction is loam and is 0 to 20 percent volcanic ash. Total rock fragment content is 20 to 50 percent.

The Bw horizon has value of 2 or 3 when moist and 4 or 5 when dry, and it has chroma of 2 or 3 when moist or dry. It is loam or clay loam and is 18 to 30 percent clay. Total rock fragment content is 35 to 75 percent.

Wickiup Series

The Wickiup series consists of very deep, poorly drained soils in depressions and swales on pumice-mantled stream terraces. These soils formed in pumice and ash. Slopes are 0 to 3 percent. The mean annual precipitation is about 20 inches, and the mean annual air temperature is about 42 degrees F.

Typical pedon of Wickiup loamy sand, 0 to 3 percent slopes; 500 feet west and 900 feet south of the northeast corner of the NW1/4 of sec. 1, T. 25 S., R. 7 E.

Oi—4 inches to 0; litter of lodgepole pine needles and huckleberry leaves and twigs.

A—0 to 4 inches; light brownish gray (10YR 5/2) loamy sand, light gray (10YR 7/1) dry; few faint very dark grayish brown (10YR 3/2) mottles; weak medium subangular blocky structure; soft, very friable, nonsticky and nonplastic; many very fine roots and few fine and medium roots; many very fine tubular pores; slightly acid (pH 6.4); clear smooth boundary.

C1—4 to 10 inches; yellowish brown (10YR 5/6) very gravelly coarse sand, very pale brown (10YR 7/4) dry; few faint very dark grayish brown (10YR 3/2) mottles; massive; loose, nonsticky and nonplastic; few fine roots; many very fine interstitial pores; 45 percent pumice gravel; slightly acid (pH 6.2); gradual wavy boundary.

C2—10 to 60 inches; yellowish brown (10YR 5/6) extremely gravelly coarse sand, white (10YR 8/2) dry; many distinct yellowish brown (10YR 5/4) mottles; massive; loose, nonsticky and nonplastic; many very fine interstitial pores; 75 percent pumice gravel; slightly acid (pH 6.2).

Depth to bedrock is more than 60 inches.

The A horizon has value of 5 or 6 when moist and 7 or 8 when dry, and it has chroma of 1 or 2 when moist or dry. It has faint dark grayish brown mottles. In some pedons the fine earth fraction includes a significant amount of diatomaceous earth that makes the horizon light colored and fine textured.

The C horizon has hue of 10YR to 5Y, value 5 or 6 when moist and 6 to 8 when dry, and chroma of 4 to 6 when moist or dry. It has faint or distinct dark grayish brown to reddish brown mottles. It is 35 to 90 percent gravel-sized pumice.

Wilt Series

The Wilt series consists of moderately deep, well drained soils on hills. These soils formed in ash over residuum. Slopes are 0 to 15 percent. The mean annual precipitation is about 16 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Wilt sandy loam, 0 to 15 percent slopes; 1,200 feet south and 200 feet east of the northwest corner of sec. 19, T. 14 S., R. 11 E.

A1—0 to 6 inches; dark brown (10YR 3/3) sandy loam, brown (10YR 5/3) dry; weak thin platy structure; slightly hard, friable, nonsticky and nonplastic; many very fine and fine roots; many very fine irregular pores; 15 percent clay; 5 percent gravel; neutral (pH 7.0); gradual smooth boundary.

A2—6 to 13 inches; dark brown (10YR 3/3) sandy loam, brown (10YR 5/3) dry; weak thin platy structure; soft, very friable, nonsticky and nonplastic; common very fine and fine roots; many very fine irregular pores; 15 percent clay; 5 percent gravel; neutral (pH 7.0); gradual wavy boundary.

2Btb1—13 to 26 inches; dark brown (10YR 3/3) cobbly loam, brown (10YR 5/3) dry; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few very fine, fine, and coarse roots and common medium roots; many fine vesicular pores and few medium tubular pores; few faint clay films on peds and few distinct clay films in pores; 15 percent gravel and 15 percent cobbles; neutral (pH 7.0); abrupt wavy boundary.

2Btb2—26 to 33 inches; dark brown (7.5YR 3/4) very cobbly clay loam, brown (7.5YR 4/4) dry; moderate fine and medium subangular blocky structure; hard, firm, sticky and plastic; few fine and medium roots; many fine vesicular pores and few fine and medium tubular pores; continuous distinct clay films on peds and in pores; 20 percent gravel and 35 percent cobbles; neutral (pH 7.0); abrupt wavy boundary.

R—33 inches; fractured andesite.

Depth to bedrock is 20 to 40 inches. The particle-size control section is 20 to 35 percent clay and averages 35 to 50 percent coarse fragments.

The A horizon has hue of 10YR, value of 3 when moist and 5 when dry, and chroma of 3 when moist or dry. It is 10 to 20 percent clay and 2 to 10 percent gravel.

The 2Btb horizon has hue of 10YR or 7.5YR, value of 3 when moist and 4 or 5 when dry, and chroma of 3 or 4 when moist or dry. The upper part of the horizon is cobbly loam or cobbly clay loam, and the lower part is very cobbly clay loam. The horizon is 20 to 35 percent clay. It is 10 to 30 percent gravel and 15 to 40 percent cobbles.

Windego Series

The Windego series consists of very deep, well drained soils on mountains. These soils formed in ash over colluvium. Slopes are 0 to 70 percent. The mean annual precipitation is about 25 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Windego sandy loam in an area of Windego-Smiling complex, 30 to 50 percent slopes; west of Forest Service Road 14, about 3/4 mile south of intersection with Forest Service Road 1495, about midslope; in the SE1/4 of sec. 3, T. 13 S., R. 9 E.

Oi—1 inch to 0; litter of ponderosa pine needles.

A1—0 to 8 inches; very dark brown (10YR 2/2) sandy loam, dark brown (10YR 3/3) dry; moderate very fine granular structure; slightly hard, friable, nonsticky and nonplastic; many very fine and fine roots; many fine interstitial pores; 10 percent gravel; neutral (pH 7.2); clear wavy boundary.

A2—8 to 19 inches; dark brown (7.5YR 3/4) sandy loam, brown (7.5YR 4/4) dry; moderate very fine granular structure; slightly hard, friable, nonsticky and nonplastic; many fine, medium, and coarse roots; many fine interstitial pores; 10 percent gravel; neutral (pH 7.2); abrupt wavy boundary.

2Btb1—19 to 30 inches; dark brown (7.5YR 3/4) very cobbly loam, brown (7.5YR 4/4) dry; moderate fine and medium subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; common medium and coarse roots; many fine interstitial and tubular pores; few faint clay films on peds and in pores; 10 percent subrounded gravel and 30 percent subrounded cobbles; neutral (pH 7.2); clear wavy boundary.

3Btb2—30 to 42 inches; dark brown (7.5YR 3/4) very cobbly clay loam, brown (7.5YR 4/4) dry; strong medium and coarse subangular blocky structure; hard, firm, slightly sticky and slightly plastic; common fine, medium, and coarse roots; many fine tubular pores; common distinct clay films on peds and in pores; 15 percent subrounded gravel and 20 percent subrounded cobbles; neutral (pH 7.0); gradual wavy boundary.

3Btb3—42 to 60 inches; very dark grayish brown (10YR 3/2) very cobbly clay loam, yellowish brown (10YR 5/4) dry; strong fine subangular blocky structure; hard, firm, sticky and plastic; few fine, medium, and coarse roots; common fine tubular pores; many distinct clay films on peds and in pores; 20 percent subrounded gravel and 30 percent subrounded cobbles; neutral (pH 7.2).

Depth to bedrock is more than 60 inches. Depth to the buried argillic horizon and thickness of the mantle of ash are 14 to 25 inches.

The O horizon is 1 to 3 inches thick except in areas that have been disturbed.

The A horizon has hue of 7.5YR or 10YR when moist or dry, value of 2 to 4 when moist and 3 to 5 when dry, and chroma of 2 to 4 when moist and 3 or 4 when dry. The horizon is 5 to 10 percent gravel and 0 to 10 percent cobbles. Total rock fragment content is 5 to 15 percent. The horizon is 5 to 15 percent clay.

The 2Btb and 3Btb horizons have hue of 5YR to 10YR when moist or dry, value of 3 when moist and 4 or 5 when dry, and chroma of 2 to 4 when moist and 4 when dry. The horizons are very cobbly loam, very cobbly clay loam, or extremely cobbly clay loam and are 18 to 35 percent clay. They are 10 to 30 percent gravel, 20 to 30 percent cobbles, and 0 to 10 percent stones. Total rock fragment content is 35 to 70 percent.

Wizard Series

The Wizard series consists of very deep, somewhat poorly drained soils on outwash plains. These soils formed in ash over glacial outwash. Slopes are 0 to 15 percent. The mean annual precipitation is about 25 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Wizard sandy loam in an area of Wizard-Allingham complex, 0 to 15 percent slopes; 100 feet southwest of Forest Service Road 1230, about 1/4 mile southeast of the intersection with Forest Service Road 1234; 200 feet north and 1,000 feet east of the southwest corner of sec. 30, T. 12 S., R. 9 E.

Oi—2 inches to 0; litter of Douglas fir, white fir, and ponderosa pine needles.

A1—0 to 7 inches; dark brown (10YR 3/3) sandy loam, yellowish brown (10YR 5/4) dry; weak medium subangular blocky structure parting to weak fine granular; slightly hard, friable, nonsticky and nonplastic; few coarse roots, common fine and medium roots, and many very fine roots; many very fine interstitial pores; 5 percent subrounded gravel; slightly acid (pH 6.4); gradual wavy boundary.

A2—7 to 23 inches; dark brown (10YR 3/3) sandy loam, yellowish brown (10YR 5/4) dry; weak medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few very fine and coarse roots and common fine and medium roots; many very fine interstitial pores; 5 percent subrounded gravel; slightly acid (pH 6.4); clear smooth boundary.

2Bwb1—23 to 28 inches; dark yellowish brown (10YR 4/4) cobbly sandy loam, light yellowish brown (10YR 6/4) dry; many coarse distinct dark brown bandlike mottles and common medium prominent strong brown diffuse round mottles; weak coarse subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few fine, medium, and coarse roots; many very fine interstitial pores; 10 percent subrounded gravel and 10 percent subrounded cobbles; neutral (pH 6.6); gradual irregular boundary.

2Bwb2—28 to 65 inches; dark yellowish brown (10YR 4/4) very cobbly sandy loam, light yellowish brown (10YR 6/4) dry; many coarse distinct dark brown bandlike mottles and common medium prominent strong brown diffuse round mottles; weak fine and medium subangular blocky structure; slightly hard, friable, nonsticky and nonplastic; few fine, medium, and coarse roots; many very fine interstitial pores; 10 percent subrounded gravel, 30 percent subrounded cobbles, and 10 percent subrounded stones; neutral (pH 6.6).

Thickness of the mantle of ash and depth to the glacial outwash material (2Bwb horizon) are 20 to 40 inches. Depth to bedrock is more than 60 inches.

The O horizon is 1 to 3 inches thick except in areas that have been disturbed.

The A horizon has 5 to 15 percent clay. It has 0 to 10 percent subrounded gravel. It is slightly acid or neutral.

The 2Bwb horizon has distinct or prominent mottles. It is cobbly sandy loam, cobbly loam, very cobbly sandy loam, or very cobbly loam and is 10 to 20 percent clay. The horizon is 5 to 25 percent subrounded gravel, 10 to 35 percent subrounded cobbles, and 0 to 15 percent subrounded stones. Total rock fragment content is 15 to 60 percent.

Xerolls

Xerolls consist of shallow to very deep, moderately well drained to somewhat excessively drained soils on hills and slumps. These soils formed in a variety of material derived from volcanic rock and ash. Slopes are 5 to 65 percent. The mean annual precipitation is about 10 inches, and the mean annual air temperature is about 48 degrees F.

Representative pedon of Xerolls, 5 to 50 percent slopes, in a roadcut along jeep trail; 650 feet west and 1,000 feet south of the northeast corner of sec. 1, T. 10 S., R. 12 E.

A1—0 to 2 inches; grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; weak thin platy structure; slightly hard, friable, slightly sticky and nonplastic; many very fine roots; many very fine interstitial pores; neutral (pH 7.0); abrupt smooth boundary.

A2—2 to 6 inches; grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and nonplastic; common very fine roots; many very fine interstitial pores; neutral (pH 7.0); gradual smooth boundary.

A3—6 to 18 inches; grayish brown (10YR 5/2) loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few medium roots; many very fine tubular pores; 10 percent gravel; moderately alkaline (pH 7.4); clear wavy boundary.

2C—18 to 60 inches; light brownish gray (10YR 6/2) sandy loam, dark brown (10YR 3/3) moist; massive; hard, firm, nonsticky and nonplastic; many very fine tubular pores; moderately alkaline (pH 7.6).

Depth to bedrock is 10 to 60 inches or more. The profile is 0 to 80 percent rock fragments.

The upper part of the A horizon has hue of 10YR, and the lower part ranges to 7.5YR. The horizon has value of 2 or 3 when moist and 4 or 5 when dry, and it has chroma of 2 or 3 when moist or dry. It is loam or very stony loam.

The 2C horizon, where present, has value of 4 to 6 when moist and 3 to 5 when dry, and it has chroma of 2 or 3 when moist or dry.

Yapoah Series

The Yapoah series consists of very deep, somewhat excessively drained soils on mountains. These soils formed in colluvium that is high in content of ash. Slopes are 0 to 75 percent. The mean annual precipitation is about 25 inches, and the mean annual air temperature is about 44 degrees F.

Typical pedon of Yapoah very cobbly loamy sand in an area of Sisters-Yapoah complex, 15 to 30 percent slopes; 500 feet south and 100 feet west of the northeast corner of the NW$^1/_4$ of sec. 9, T. 17 S., R. 10 E.

Oi—2 inches to 0; ponderosa pine and white fir needles and twigs.

A—0 to 12 inches; dark brown (10YR 3/3) very cobbly loamy sand, brown (10YR 5/3) dry; weak fine granular structure; loose, nonsticky and nonplastic; many very fine and fine roots, common medium roots, and few coarse roots; many very fine interstitial pores; 10 percent subangular gravel and 30 percent subangular cobbles; 40 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.0); gradual wavy boundary.

C1—12 to 33 inches; dark yellowish brown (10YR 3/4) extremely flaggy loamy sand, yellowish brown (10YR 5/4) dry; single grain; loose, nonsticky and nonplastic; few fine, medium, and coarse roots; many very fine interstitial pores; 10 percent subangular gravel, 50 percent flagstones, and 10 percent stones; 40 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.0); gradual wavy boundary.

C2—33 to 60 inches; dark yellowish brown (10YR 3/4) extremely flaggy loamy sand, light yellowish brown (10YR 6/4) dry; single grain; loose, nonsticky and nonplastic; few fine, medium, and coarse roots; many very fine interstitial pores; 10 percent subangular gravel, 50 percent flagstones, and 10 percent stones; 30 percent pumice (0.5 to 2.0 millimeters); neutral (pH 7.0).

Depth to bedrock is more than 60 inches.

The A horizon has hue of 10YR or 7.5YR, value of 2 or 3 when moist and 4 or 5 when dry, and chroma of 2 or 3 when moist and 3 or 4 when dry. The horizon is 10 to 20 percent gravel and 25 to 35 percent cobbles. Total rock ragment content is 35 to 55 percent. The horizon is 25 to 40 percent pumice (0.5 to 2.0 millimeters).

The C horizon has value of 3 to 5 when moist and 5 to 7 when dry, and it has chroma of 4 to 6 when moist or dry. It is very cobbly, extremely cobbly, very flaggy, or extremely flaggy loamy sand. The horizon is 10 to 20 percent gravel, 30 to 50 percent cobbles, and 0 to 10 percent stones. Total rock fragment content is 40 to 80 percent. The horizon is 30 to 60 percent pumice (0.5 to 2.0 millimeters).

Formation of the Soils

Soil is a natural, three-dimensional body on the earth's surface that supports plants. Its characteristics and properties are determined by physical and chemical processes that result from the interaction of five factors—parent material, climate, time, relief, and plant and animal life.

The influence of each factor varies from place to place, and some factors are more dominant than others. The interaction of all the factors determines the kind of soil that forms. Most of the differences in the soils in this survey area are the result of three factors—parent material, climate, and relief.

Parent Material

The characteristics of the parent material in which soils form have a profound initial impact on soil properties. Texture, permeability, bulk density, and fertility of young soils are affected by the nature of the parent material. The influence of parent material on soil formation and development decreases over time.

The soils in this survey area formed in material primarily of volcanic origin. Volcanic material, including basalt, andesite, rhyolite, tuff, pumice, and ash, is common. Substrata of volcaniclastic sediment, such as pumice, ash, and cinders, also are common, especially near the foot slopes of the Cascade Mountains. Soils underlain by glacial outwash and till are in the westernmost parts of Deschutes and Jefferson Counties.

The oldest geologic formations in the survey area, which are 25 to 50 million years old, are in the eastern part of Jefferson County and in small areas in the eastern part of Deschutes County *(5)*. The degree of soil development on the John Day and Clarno Formations reflects long periods of geologic time. The Simas and Tub soils have a high content of clay, most of which has high shrink-swell potential such as does montmorillonite; an argillic or calcic horizon, or both; and high chroma.

Fluvial and lacustrine sediment of the Deschutes Formation, which was deposited 2 to 6 million years ago, underlies much of the Deschutes Basin, from Bend north to Gateway in the northwestern part of Jefferson County *(15)*. The Deschutes Formation consists mainly of volcanic sand, gravel, and silt deposited in horizontal beds or reworked by wind and water. Included within the formation are welded tuff and interbedded lava flows that occur as rimrock on buttes and along canyon walls. The volcanic rock and sediment in the Deschutes Formation is from the Broken Top-Three Sisters area of the High Cascades. Preferential erosion has redeposited the unconsolidated material from the High Cascades onto the slopes of Green Ridge and into the Deschutes Basin *(18)*. Superimposed over these areas is a mantle of volcanic ash deposited during the eruption of Mt. Mazama. The mantle is thickest in the southern part of the survey area and is thin and discontinuous in the northern part.

On Green Ridge, deep and moderately deep, soils such as those of the Gap, Glaze, Prairie, Windego, and Smiling series, have layers of ash over fine-textured buried material derived from the underlying basalt or tuff. In the northeastern part of the survey area are soils that have a fine-textured subsoil, but they have little, if any, volcanic ash in the surface layer. Moderately deep and shallow soils, such as those of the Searles, Holmzie, Madras, and Agency series, are examples. Soils such as those of the Redcliff, Redslide, and Lickskillet series formed along the margins of the rimrock in areas of colluvium and residuum derived from basalt. Era soils formed in old stream channel deposits. These soils are very deep and coarse textured and are underlain by sand and gravel of the Deschutes Formation.

In some areas are erosional remnants of lacustrine deposits of diatomite that have a rolling topography and predictable soil patterns. Buckbert soils, which are deep and medium textured, formed in the depressions containing sediment derived from the surrounding slopes. Lafollette soils are underlain by sand and gravel of the Deschutes Formation. These soils formed on the stream terraces in areas where a mantle of ash about 24 inches thick was blown in or washed in from the uplands. Tetherow soils, which are similar to the

Lafollette soils, are underlain by cinders. The cinder cones west of Terrebonne, in the northern part of Deschutes County, are the source of this material.

The basalt flows near Bend and Redmond issued from vents in Newberry Volcano and High Cascades volcanoes. These flows are among the youngest surfaces in the survey area, having been laid down less than 2 million years ago. Soils on these flows are transitional between the coarse-textured pumice soils of the LaPine Basin and the finer textured soils in the northern part of the area. Varying amounts of volcanic ash have been moved from rock outcroppings and redeposited in depressions. Deschutes and Deskamp soils are in these depressions, and Stukel and Gosney soils are in the slightly higher positions along the margins of the depressions and rock outcroppings. Deskamp and Gosney soils are loamy sand because of their proximity to Mt. Mazama, but Deschutes and Stukel soils are dominantly sandy loam. Houstake soils are similar to the Deschutes soils except that they are deeper to basalt and have more cementation in the lower part of the profile. Statz soils, on older basalt lava flows, exhibit the most soil development. They have a well-developed, silica-cemented duripan.

Soils in the eastern part of the survey area (east of Horse Ridge) are distinctly different from those in the Cascade Range. The soils on plains, benches, and basins are moderately deep to very deep to bedrock or to a duripan. They are high in content of volcanic ash that originated from Newberry Volcano or Mt. Mazama. Soils of the Borobey, Gardone, Milcan, and Stookmoor series are examples. In contrast, the soils of the uplands formed in older material of the Pliocene and Pleistocene. These soils are shallow or moderately deep to bedrock or to a duripan. They typically do not have an influence of volcanic ash on the surface, but they have a fine- or medium-textured argillic horizon that is high in content of montmorillonite. Soils of the Ninemile, Menbo, and Beden series are examples. Lake sediment and windblown material accumulated in the smaller basins and playas. Soils such as those of the Swaler and Swalesilver series are in these basins and playas.

A large deposit of Mt. Mazama ash and pumice is within the broad LaPine Basin, between Newberry Volcano and the Cascade Mountains south of Bend. The basin was formed by basalt flows that dammed the Deschutes River near Benham Falls. The Deschutes and Little Deschutes Rivers meander through the area, indicating that the present base level has existed for a considerable period of time. The soils in this area are porous and have distinctive characteristics, such as low bulk density, low heat capacity, low thermal conductivity, and very high available water capacity. Permeability is rapid or very rapid. The thickness of the mantle of ash, depth to a buried soil, and size of pumice fragments decrease as the distance from Mt. Mazama increases.

At the south end of LaPine Basin, the mantle of ash is as much as 10 feet thick. Lapine soils are on the uplands and pumice plains. These soils typically are coarse-textured ash and pumice throughout, and pumice fragments more than 2 millimeters in diameter make up much of the volume. Further north are the Steiger soils that are similar in texture to the Lapine soils, but they have fewer pumice fragments by volume. The Steiger soils have a loam or sandy loam buried soil at a depth of 40 to 60 inches or more. The Shanahan soils are at the northern end of the basin. These soils have a mantle of ash 20 to 40 inches thick over a buried soil, and the volume of pumice fragments is less than that of the Steiger soils.

Associated with the well drained to excessively well drained Lapine, Steiger, and Shanahan soils are the somewhat poorly drained Wickiup, Tutni, and Sunriver soils, respectively. These soils are on stream terraces between the drainageways and the uplands. They are similar in appearance to the upland soils except that they have mottles in the profile, which indicates the presence of a high water table at times during the year. Within the main drainageways of the Deschutes and Little Deschutes Rivers are poorly drained and very poorly drained soils that have a dark surface layer that varies in texture. These soils were laid down during flooding. Layers of volcanic ash are common in the profile. Another common feature is a layer of diatomite, which is a siliceous sedimentary material that formed from one-celled algae, called diatoms, and has low bulk density. These plants form in cold, shallow lacustrine environments that have a ready source of silica *(11)*.

At least three times in the last 100,000 years, glacial ice has covered the Cascade Mountains. The glacial moraines that formed were then blanketed with volcanic ash and cinders from local sources. The Bott and Minkwell soils typically have 24 inches of volcanic ash from High Cascades volcanoes and other sources over a buried soil of glacial till consisting of extremely cobbly or stony loam or clay loam. Soils such as those of the Belrick and Linksterly series have layers of distinctive scoria or fine ash, or both, from local sources, notably Blue Lake and Sand Mountain. Glacial outwash deposits consisting of cobbles, sand, and gravel have been incised locally by stream channels. These deposits form outwash fans and plains at the lower elevations. Soils that formed on these outwash deposits are differentiated by the thickness of the mantle of ash. The Allingham and

Wizard soils typically have a cobbly, very cobbly, or very gravelly loam or clay loam buried soil at a depth of 20 to 40 inches. The Circle and Suilotem soils have a similar buried soil at a depth of 40 to 60 inches. The Plainview and Tumalo soils formed in moderately extensive deposits of glacial outwash west of Tumalo. These soils are drier, and they exhibit less weathering of the ash than do the more moist Allingham, Wizard, Circle, and Suilotem soils.

Climate

The Cascade Mountains form the western boundary of the survey area and act as a barrier to airmasses moving in from the Pacific Ocean. These mountains separate western Oregon, which has a wetter and milder climate, from eastern Oregon, which has a drier, continental climate.

The two most commonly measured climatic factors influencing soil formation are precipitation and temperature. These factors determine the rate and type of physical and chemical reactions that occur in a soil. In general, precipitation and temperature affect soil development and behavior by controlling chemical reactions, physical processes, and the activity of soil organisms *(13)*.

Three distinct climatic zones based on temperature and precipitation are in the survey area. In the forested foot slopes of the Cascade Mountains, the mean annual precipitation ranges from about 80 inches near the crest of the Cascades to about 25 inches near Sisters. Most of the soils in this zone have a layer of ash or scoria derived from local sources and an underlying buried soil. The water passing through the soil leaches exchangeable bases from the surface layer into the subsoil and concentrates hydrogen and aluminum ions in the surface layer; therefore, reaction (pH) of the surface layer is neutral or slightly acid. These soils have a thin surface layer that is 2 percent organic matter or more. The plant community consists of conifers and evergreen shrubs that produce large amounts of material for decomposition. The rate of decomposition, however, is controlled by a combination of factors, such as cold soil temperature. The content of clay in the mantle of ash generally is quite low, usually less than 10 percent, but it increases dramatically in the soils that have a buried argillic horizon. These residual soils probably were formed in ash and basalt deposited when the climate was warmer and more humid.

To the east of the Cascade Mountains, the mean annual precipitation decreases rapidly. This is the transition zone separating the soils of the mountains from those of the desert. From Sisters east to about the Deschutes River, precipitation ranges from 18 to 25 inches. Soil temperatures are warmer in this zone than in the mountains, reaction (pH) is near neutral throughout the profile, and total exchangeable bases is higher. The vegetation is dominantly shrubs and grasses with fewer conifers; thus, the content of organic matter is much lower. In some areas of rangeland, overgrazing by livestock has reduced the plant cover. In the soils that have a large amount of ash and pumice in the surface layer, fluctuations in the temperature of the surface layer are extreme. This is a result of the light color reflecting solar radiation and the low heat capacity of the porous pumice. The content of clay is low in these soils because the deposits are young, and the weathering of minerals is slow because of the lack of moisture.

The soils in the high desert in the eastern part of the survey area (east of Horse Ridge) have a mean annual precipitation of 8 to 12 inches. The vegetation is shrubs, grasses, and a few trees. The content of organic matter is low. Because of the low precipitation, total exchangeable bases is high and free carbonates occur as nodules in the profile and as coatings on the bedrock and coarse fragments. Reaction (pH) in the surface layer is neutral or slightly alkaline, and alkalinity increases as depth increases. The content of clay is low, and fluctuations in the soil temperature are extreme.

Time

The rate of soil formation is measured by the degree of soil horizonation. The influence of time is measured from “the point in time at which a pedalogically catastrophic event is complete, initiating a new cycle of soil development” *(8)*. The catastrophe may be geologic, such as deposition of new material on an existing soil or uplifting of a land mass, or climatic, such as a major change in environmental conditions. Human activity can also affect soil development.

With few exceptions, soil development in central Oregon can be traced from the Pliocene to the present, which covers a span of about 5 million years *(29)*. Although uplift was already occurring in the Cascade Range, the formation of the High Cascades began with the growth of broad shield volcanoes during the beginning of the Pliocene. Basalt and andesite flows from these volcanoes contributed further to the separation of western and eastern Oregon along a north-south mountain belt. Flows of hot mud and ash and waterborne debris, such as sand, gravel, and boulders, swept down from the volcanoes onto the gentler slopes below. During the following millennia, the growth of the High Cascades continued and the climate changed to about what it is at present. Conditions were favorable for weathering and translocating soil material. An argillic horizon formed in many soils until they were covered by layers of volcanic ash during the Pleistocene, beginning about 2 million years ago. Most notable and useful as a benchmark for measuring change was the eruption of Mt. Mazama about 6,600 years ago. Ash was deposited from south to north over most of central Oregon. Very little soil development has taken place in this mantle of ash. Thin A horizons have developed, and weakly developed B horizons are apparent from the increased structure (cambic horizon), weak cementation, and chemical weathering of the ash.

During the Pleistocene, large volumes of basalt from the High Cascades volcanoes and Newberry Volcano covered the landscape. Insufficient time has passed for development of horizons in this material. The typical profile of soils in these areas is a layer of ash over bedrock. Some soils have a weakly cemented to indurated duripan as a result of silica being leached and redeposited.

The LaPine Basin is a lake basin that formed as a result of lava flows damming the Deschutes River. It contains a broad expanse of Mt. Mazama pumice and ash deposited over stream or lake deposits of diatomite, peat, silt, and sand. Soil development is very slow because of the sterile nature of the pumice and ash and the cold soil temperatures. Thin A horizons have formed in this material, but there is no evidence of development of B horizons. The mantle of pumice and ash is more than 60 inches thick in the southern part of the basin, but it grades to about 24 inches thick near Bend.

Relief

Relief is the elevations or inequalities of the land surface *(22)*. The main factors of relief taken into account are slope, aspect, elevation, and the site-specific microrelief features. These factors affect soil properties independently and in combination with the other factors of soil formation.

Relief has different effects under different environmental conditions. It modifies the influence of parent material and time affecting the erosion and deposition that takes place. It alters climate by increasing or decreasing effective moisture and temperature; consequently, the kinds and abundance of plants vary with aspect *(8)*.

The Cascade Mountains have had a major influence on soil development in central Oregon. They alter the easterly movement of the moist, warm Pacific airmasses and create a rainshadow on the eastern slopes. Elevation in the survey area ranges from 2,500 feet near Madras in the northern part to nearly 5,000 feet in eastern part.

Slope gradient is an important factor in soil formation. The infiltration of water decreases and the amount of runoff increases as slope increases. Slope gradient and shape are related to the underlying lithology and its age. The broad basalt shield volcanoes of the High Cascades generally have moderately steep or steep slopes that rarely are more than 50 percent. The soils are deep and well drained. The outwash plains typically are gently sloping to strongly sloping. The soils are very deep and well drained and may or may not have discontinuities of gravelly outwash. Landforms of the Pliocene or older, such as Cline Buttes, Pine Mountain, and Juniper Butte, that are composed of andesite and rhyolite have the classic shape of older surfaces, including distinct convex, eroding upper slopes and concave, depositional lower slopes. Soils on the upper slopes may have a significant amount of cobbles and stones, while those on the lower slopes are deep and relatively free of stones. The canyons consist of cliffs, debris slopes, and fans *(29)* The thickness of the soils in the canyons is highly variable because of erosion and deposition, and areas of Rock outcrop and Rubble land are common. The plateaus that form the tops of the basalt flows are nearly level to moderately sloping and have stable surfaces. The soils on the plateaus are shallow to moderately deep and have a developed duripan or argillic horizon. Landforms throughout the survey area are modified by a mantle of volcanic ash that softens the appearance of the landscape.

Aspect, or the direction in which a slope faces, is another important feature of relief. Soils that formed on south-facing slopes usually are warmer and drier, have less biomass, and have a lower organic matter content in the surface layer than those on north-facing slopes.

An interesting phenomenon related to relief, found mainly in the LaPine Basin, is the difference in plant communities that occurs with minor changes in elevation. Frost pockets develop in the depressions because the cold air tends to follow the contour of the landscape. As a result, lodgepole pine grows in the depressions or low areas and ponderosa pine is the dominant species in the higher areas. Lodgepole pine seedlings are more tolerant of the cold temperatures at night and are tolerant of wetness in areas that have a high water table.

Plant and Animal Life

Plants and animals, including man, affect and are affected by the soils. The kinds of plants and animals present also are influenced by the other soil-forming factors.

Soil micro-organisms decompose much of the dead plant material and aid in recycling nutrients into the soil. Earthworms, ants, and burrowing creatures mix soil horizons in areas of favorable moisture conditions.

Changes in vegetation in the survey area are the result of differences in elevation, temperature, and precipitation. The vegetation in the Cascade Mountains consists of commercial-grade timber species such as Douglas fir and ponderosa pine. Understory vegetation commonly consists of snowbrush, manzanita, and other shrubs and grasses. The decomposing litter results in dark-colored soils that have a thick organic layer on the surface and mineral horizons that are high in bases.

In the forest-range transitional areas, the tree species consist of ponderosa pine and western juniper and the understory vegetation is mainly antelope bitterbrush and sagebrush. The relatively recent deposition of ash, the low precipitation, and the limited amount of organic material produce soils that have a low content of organic matter, are light colored, and have weak structure.

In the LaPine Basin, the soils on the terrace adjacent to the stream channel formed under a plant cover of willow, sedges, forbs, and grasses. These poorly drained soils have a thick organic surface layer over layers of pumice. The soils on the adjacent higher terrace are somewhat poorly drained and support lodgepole pine with an understory of bearberry, strawberry, and long-stemmed clover. These soils have a lower organic matter content than do the soils on the lower terrace.

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Glossary

ABC soil. A soil having an A, a B, and a C horizon.

AC soil. A soil having only an A and a C horizon. Commonly, such soil formed in recent alluvium or on steep, rocky slopes.

Aeration, soil. The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alluvial cone. The material washed down the sides of mountains and hills by ephemeral streams and deposited at the mouth of gorges in the form of a moderately steep, conical mass descending equally in all directions from the point of issue.

Alluvial fan. The fanlike deposit of a stream where it issues from a gorge upon a plain or of a tributary stream near or at its junction with its main stream.

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Alpha,alpha-dipyridyl. A dye that when dissolved in 1N ammonium acetate is used to detect the presence of reduced iron (Fe II) in the soil. A positive reaction indicates a type of redoximorphic feature.

Andic soil properties. A collection of physical and chemical properties given in “Keys to Soil Taxonomy” that are the taxonomic criteria for the Andisol order.

Animal unit month (AUM). The amount of forage required by one mature cow of approximately 1,000 pounds weight, with or without a calf, for 1 month.

Aquic conditions. Current soil wetness characterized by saturation, reduction, and redoximorphic features.

Area reclaim (in tables). An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Argillic horizon. A subsoil horizon characterized by an accumulation of illuvial clay.

Aspect. The direction in which a slope faces.

Association, soil. A group of soils or miscellaneous areas geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as:

Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	9 to 12
Very high	more than 12

Back slope. The geomorphic component that forms the steepest inclined surface and principal element of many hillsides. Back slopes in profile are commonly steep, are linear, and may or may not include cliff segments.

Badland. Steep or very steep, commonly nonstony, barren land dissected by many intermittent drainage channels. Badland is most common in semiarid and arid regions where streams are entrenched in soft geologic material. Local relief generally ranges from 25 to 500 feet. Runoff potential is very high, and geologic erosion is active.

Basal area. The area of a cross section of a tree, generally referring to the section at breast height and measured outside the bark. It is a measure of stand density, commonly expressed in square feet.

Base saturation. The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, and K), expressed as a percentage of the total cation-exchange capacity.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bedrock-controlled topography. A landscape where the configuration and relief of the landforms are determined or strongly influenced by the underlying bedrock.

Bench terrace. A raised, level or nearly level strip of earth constructed on or nearly on a contour, supported by a barrier of rocks or similar material, and designed to make the soil suitable for tillage and to prevent accelerated erosion.

Blowout. A shallow depression from which all or most of the soil material has been removed by the wind. A blowout has a flat or irregular floor formed by a resistant layer or by an accumulation of pebbles or cobbles. In some blowouts the water table is exposed.

Bottom land. The normal flood plain of a stream, subject to flooding.

Boulders. Rock fragments larger than 2 feet (60 centimeters) in diameter.

Breaks. The steep and very steep broken land at the border of an upland summit that is dissected by ravines.

Breast height. An average height of 4.5 feet above the ground surface; the point on a tree where diameter measurements are ordinarily taken.

Brush management. Use of mechanical, chemical, or biological methods to make conditions favorable for reseeding or to reduce or eliminate competition from woody vegetation and thus allow understory grasses and forbs to recover. Brush management increases forage production and thus reduces the hazard of erosion. It can improve the habitat for some species of wildlife.

Butte. An isolated small mountain or hill with steep or precipitous sides and a top variously flat, rounded, or pointed that may be a residual mass isolated by erosion or an exposed volcanic neck.

Cable yarding. A method of moving felled trees to a nearby central area for transport to a processing facility. Most cable yarding systems involve use of a drum, a pole, and wire cables in an arrangement similar to that of a rod and reel used for fishing. To reduce friction and soil disturbance, felled trees generally are reeled in while one end is lifted or the entire log is suspended.

Calcareous soil. A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Canopy. The leafy crown of trees or shrubs. (See Crown.)

Canyon. A long, deep, narrow, very steep sided valley with high, precipitous walls in an area of high local relief.

Capillary water. Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Catena. A sequence, or “chain,” of soils on a landscape that formed in similar kinds of parent material but have different characteristics as a result of differences in relief and drainage.

Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

Channery soil material. Soil material that is, by volume, 15 to 35 percent thin, flat fragments of sandstone, shale, slate, limestone, or schist as much as 6 inches (15 centimeters) along the longest axis. A single piece is called a channer.

Chemical treatment. Control of unwanted vegetation through the use of chemicals.

Chiseling. Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard, compacted layers to a depth below normal plow depth.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay depletions. Low-chroma zones having a low content of iron, manganese, and clay because of the chemical reduction of iron and manganese and the removal of iron, manganese, and clay. A type of redoximorphic depletion.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Claypan. A slowly permeable soil horizon that contains much more clay than the horizons above it. A claypan is commonly hard when dry and plastic or stiff when wet.

Climax plant community. The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

Coarse textured soil. Sand or loamy sand.

Cobble (or cobblestone). A rounded or partly rounded fragment of rock 3 to 10 inches (7.6 to 25 centimeters) in diameter.

Cobbly soil material. Material that is 15 to 35 percent, by volume, rounded or partially rounded rock fragments 3 to 10 inches (7.6 to 25 centimeters) in diameter. Very cobbly soil material has 35 to 60 percent of these rock fragments, and extremely cobbly soil material has more than 60 percent.

Colluvium. Soil material or rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

Complex slope. Irregular or variable slope. Planning or establishing terraces, diversions, and other water-control structures on a complex slope is difficult.

Complex, soil. A map unit of two or more kinds of soil or miscellaneous areas in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas.

Compressible (in tables). Excessive decrease in volume of soft soil under load.

Concretions. Cemented bodies with crude internal symmetry organized around a point, a line, or a plane. They typically take the form of concentric layers visible to the naked eye. Calcium carbonate, iron oxide, and manganese oxide are common compounds making up concretions. If formed in place, concretions of iron oxide or manganese oxide are generally considered a type of redoximorphic concentration.

Conglomerate. A coarse grained, clastic rock composed of rounded or subangular rock fragments more than 2 millimeters in diameter. It commonly has a matrix of sand and finer textured material. Conglomerate is the consolidated equivalent of gravel.

Conservation cropping system. Growing crops in combination with needed cultural and management practices. In a good conservation cropping system, the soil-improving crops and practices more than offset the effects of the soil-depleting crops and practices. Cropping systems are needed on all tilled soils. Soil-improving practices in a conservation cropping system include the use of rotations that contain grasses and legumes and the return of crop residue to the soil. Other practices include the use of green manure crops of grasses and legumes, proper tillage, adequate fertilization, and weed and pest control.

Conservation tillage. A tillage system that does not invert the soil and that leaves a protective amount of crop residue on the surface throughout the year.

Consistence, soil. Refers to the degree of cohesion and adhesion of soil material and its resistance to deformation when ruptured. Consistence includes resistance of soil material to rupture and to penetration; plasticity, toughness, and stickiness of puddled soil material; and the manner in which the soil material behaves when subject to compression. Terms describing consistence are defined in the “Soil Survey Manual.”

Contour stripcropping. Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Control section. The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

Corrosion. Soil-induced electrochemical or chemical action that dissolves or weakens concrete or uncoated steel.

Cover crop. A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Cropping system. Growing crops according to a planned system of rotation and management practices.

Crop residue management. Returning crop residue to the soil, which helps to maintain soil structure, organic matter content, and fertility and helps to control erosion.

Cross-slope farming. Deliberately conducting farming operations on sloping farmland in such a way that tillage is across the general slope.

Crown. The upper part of a tree or shrub, including the living branches and their foliage.

Culmination of the mean annual increment (CMAI). The average annual increase per acre in the volume of a stand. Computed by dividing the total volume of the stand by its age. As the stand increases in age, the mean annual increment continues to increase until mortality begins to reduce the rate of increase. The point where the stand reaches its maximum annual rate of growth is called the culmination of the mean annual increment.

Cutbanks cave (in tables). The walls of excavations tend to cave in or slough.

Decreasers. The most heavily grazed climax range plants. Because they are the most palatable, they are the first to be destroyed by overgrazing.

Deferred grazing. Postponing grazing or resting grazing land for a prescribed period.

Dense layer (in tables). A very firm, massive layer that has a bulk density of more than 1.8 grams per cubic centimeter. Such a layer affects the ease of digging and can affect filling and compacting.

Depth, soil. Generally, the thickness of the soil over bedrock. Very deep soils are more than 60 inches deep over bedrock; deep soils, 40 to 60 inches; moderately deep, 20 to 40 inches; shallow, 10 to 20 inches; and very shallow, less than 10 inches.

Depth to rock (in tables). Bedrock is too near the surface for the specified use.

Desert pavement. On a desert surface, a layer of gravel or larger fragments that was emplaced by upward movement of the underlying sediments or that remains after finer particles have been removed by running water or the wind.

Dip slope. A slope of the land surface, roughly determined by and approximately conforming to the dip of the underlying bedrock.

Diversion (or diversion terrace). A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Divided-slope farming. A form of field stripcropping in which crops are grown in a systematic arrangement of two strips, or bands, across the slope to reduce the hazard of water erosion. One strip is in a close-growing crop that provides protection from erosion, and the other strip is in a crop that provides less protection from erosion. This practice is used where slopes are not long enough to permit a full stripcropping pattern to be used.

Drainage class (natural). Refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized—*excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained,* and *very poorly drained*. These classes are defined in the “Soil Survey Manual.”

Drainage, surface. Runoff, or surface flow of water, from an area.

Draw. A small stream valley that generally is more open and has broader bottom land than a ravine or gulch.

Duff. A generally firm organic layer on the surface of mineral soils. It consists of fallen plant material that is in the process of decomposition and includes everything from the litter on the surface to underlying pure humus.

Duripan. A subsurface horizon that is cemented by silica to the degree that less than 50 percent of the volume of an air-dried fragment slakes in water or acid.

Eluviation. The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Eolian soil material. Earthy parent material accumulated through wind action; commonly refers to sandy material in dunes or to loess in blankets on the surface.

Ephemeral stream. A stream, or reach of a stream, that flows only in direct response to precipitation. It receives no long-continued supply from melting snow or other source, and its channel is above the water table at all times.

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of human or animal activities or of a catastrophe in nature, such as a fire, that exposes the surface.

Escarpment. A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and resulting from erosion or faulting. Synonym: scarp.

Excess fines (in tables). Excess silt and clay in the soil. The soil does not provide a source of gravel or sand for construction purposes.

Excess lime (in tables). Excess carbonates in the soil that restrict the growth of some plants.

Excess salts (in tables). Excess water-soluble salts in the soil that restrict the growth of most plants.

Excess sodium (in tables). Excess exchangeable sodium in the soil. The resulting poor physical properties restrict the growth of plants.

Excess sulfur (in tables). Excessive amount of sulfur in the soil. The sulfur causes extreme acidity if the soil is drained, and the growth of most plants is restricted.

Extrusive rock. Igneous rock derived from deep-seated molten matter (magma) emplaced on the earth’s surface.

Fallow. Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grain is grown. The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

Fan terrace. A relict alluvial fan, no longer a site of active deposition, incised by younger and lower alluvial surfaces.

Fast intake (in tables). The rapid movement of water into the soil.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity*.

Fill slope. A sloping surface consisting of excavated soil material from a road cut. It commonly is on the downhill side of the road.

Fine textured soil. Sandy clay, silty clay, or clay.

Firebreak. Area cleared of flammable material to stop or help control creeping or running fires. It also serves as a line from which to work and to facilitate the movement of firefighters and equipment. Designated roads also serve as firebreaks.

Flaggy soil material. Material that is, by volume, 15 to 35 percent flagstones. Very flaggy soil material has 35 to 60 percent flagstones, and extremely flaggy soil material has more than 60 percent flagstones.

Flagstone. A thin fragment of sandstone, limestone, slate, shale, or (rarely) schist 6 to 15 inches (15 to 38 centimeters) long.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Fluvial. Of or pertaining to rivers; produced by river action, as a fluvial plain.

Foothill. A steeply sloping upland that has relief of as much as 1,000 feet (300 meters) and fringes a mountain range or high-plateau escarpment.

Foot slope. The inclined surface at the base of a hill.

Forb. Any herbaceous plant not a grass or a sedge.

Forest cover. All trees and other woody plants (underbrush) covering the ground in a forest.

Forest type. A stand of trees similar in composition and development because of given physical and biological factors by which it may be differentiated from other stands.

Fragile (in tables). A soil that is easily damaged by use or disturbance.

Frost action (in tables). Freezing and thawing of soil moisture. Frost action can damage roads, buildings and other structures, and plant roots.

Genesis, soil. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Glacial outwash. Gravel, sand, and silt, commonly stratified, deposited by glacial meltwater.

Glacial till. Unsorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Glaciofluvial deposits. Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur as kames, eskers, deltas, and outwash plains.

Gleyed soil. Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors.

Graded stripcropping. Growing crops in strips that grade toward a protected waterway.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel. Rounded or angular fragments of rock as much as 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravelly soil material. Material that is 15 to 35 percent, by volume, rounded or angular rock fragments, not prominently flattened, as much as 3 inches (7.6 centimeters) in diameter.

Green manure crop (agronomy). A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

Ground water. Water filling all the unblocked pores of the material below the water table.

Gully. A miniature valley with steep sides cut by running water and through which water ordinarily runs only after rainfall. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage.

Hard bedrock. Bedrock that cannot be excavated except by blasting or by the use of special equipment that is not commonly used in construction.

Hardpan. A hardened or cemented soil horizon, or layer. The soil material is sandy, loamy, or clayey and is cemented by iron oxide, silica, calcium carbonate, or other substance.

High-residue crops. Such crops as small grain and corn used for grain. If properly managed, residue from these crops can be used to control erosion until the next crop in the rotation is established. These crops return large amounts of organic matter to the soil.

Hill. A natural elevation of the land surface, rising as much as 1,000 feet above surrounding lowlands, commonly of limited summit area and having a well defined outline; hillsides generally have slopes of more than 15 percent. The distinction between a hill and a mountain is arbitrary and is dependent on local usage.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the “Soil Survey Manual.” The major horizons of mineral soil are as follows:

O horizon.—An organic layer of fresh and decaying plant residue.

A horizon.—The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

E horizon.—The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying soil material. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon.—Soft, consolidated bedrock beneath the soil.

R layer.—Consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon, but it can be directly below an A or a B horizon.

Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups. Refers to soils grouped according to their runoff potential. The soil properties that influence this potential are those that affect the minimum rate of water infiltration on a bare soil during periods after prolonged wetting when the soil is not frozen. These properties are depth to a seasonal high water table, the infiltration rate and permeability after prolonged wetting, and depth to a very slowly permeable layer. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff.

Igneous rock. Rock formed by solidification from a molten or partially molten state. Major varieties include plutonic and volcanic rock. Examples are andesite, basalt, and granite.

Illuviation. The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Impervious soil. A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Increasers. Species in the climax vegetation that increase in amount as the more desirable plants are reduced by close grazing. Increasers commonly are the shorter plants and the less palatable to livestock.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration capacity. The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Intake rate. The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake, in inches per hour, is expressed as follows:

Less than 0.2	very low
0.2 to 0.4	low
0.4 to 0.75	moderately low
0.75 to 1.25	moderate
1.25 to 1.75	moderately high
1.75 to 2.5	high
More than 2.5	very high

Intermittent stream. A stream, or reach of a stream, that flows for prolonged periods only when it receives ground-water discharge or long, continued contributions from melting snow or other surface and shallow subsurface sources.

Invaders. On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, plants invade following disturbance of the surface.

Iron depletions. Low-chroma zones having a low content of iron and manganese oxide because of chemical reduction and removal, but having a clay content similar to that of the adjacent matrix. A type of redoximorphic depletion.

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are:

Basin.—Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Border.—Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Controlled flooding.—Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation.—Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle).—Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow.—Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler.—Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation.—Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding.—Water, released at high points, is allowed to flow onto an area without controlled distribution.

Knoll. A small, low, rounded hill rising above adjacent landforms.

Lacustrine deposit. Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Landslide. The rapid downhill movement of a mass of soil and loose rock, generally when wet or saturated. The speed and distance of movement, as well as the amount of soil and rock material, vary greatly.

Large stones (in tables). Rock fragments 3 inches (7.6 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Lava plain. A broad area of level or nearly level land, usually hundreds of square miles in extent, that is underlain by a relatively thin succession of basaltic lava flows resulting from fissure eruptions.

Leaching. The removal of soluble material from soil or other material by percolating water.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess. Fine grained material, dominantly of silt-sized particles, deposited by wind.

Low-residue crops. Such crops as corn used for silage, peas, beans, and potatoes. Residue from these crops is not adequate to control erosion until the next crop in the rotation is established. These crops return little organic matter to the soil.

Low strength. The soil is not strong enough to support loads.

Masses. Concentrations of substances in the soil matrix that do not have a clearly defined boundary with the surrounding soil material and cannot be removed as a discrete unit. Common compounds making up masses are calcium carbonate, gypsum or other soluble salts, iron oxide, and manganese oxide. Masses consisting of iron oxide or manganese oxide generally are considered a type of redoximorphic concentration.

Mechanical treatment. Use of mechanical equipment for seeding, brush management, and other management practices.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Mesa. A broad, nearly flat topped and commonly isolated upland mass characterized by summit widths that are more than the heights of bounding erosional scarps.

Metamorphic rock. Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement. Nearly all such rocks are crystalline.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Minimum tillage. Only the tillage essential to crop production and prevention of soil damage.

Miscellaneous area. An area that has little or no natural soil and supports little or no vegetation.

Moderately coarse textured soil. Coarse sandy loam, sandy loam, or fine sandy loam.

Moderately fine textured soil. Clay loam, sandy clay loam, or silty clay loam.

Mollic epipedon. A thick, dark, humus-rich surface horizon (or horizons) that has high base saturation and pedogenic soil structure. It may include the upper part of the subsoil.

Moraine. An accumulation of earth, stones, and other debris deposited by a glacier. Some types are terminal, lateral, medial, and ground.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil. Irregular spots of different colors that vary in number and size. Descriptive terms are as follows: abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium,* from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse,* more than 15 millimeters (about 0.6 inch).

Mountain. A natural elevation of the land surface, rising more than 1,000 feet above surrounding lowlands, commonly of restricted summit area (relative to a plateau) and generally having steep sides. A mountain can occur as a single, isolated mass or in a group forming a chain or range.

Munsell notation. A designation of color by degrees of three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with hue of 10YR, value of 6, and chroma of 4.

Neutral soil. A soil having a pH value of 6.6 to 7.3. (See Reaction, soil.)

Nodules. Cemented bodies lacking visible internal structure. Calcium carbonate, iron oxide, and manganese oxide are common compounds making up nodules. If formed in place, nodules of iron oxide or manganese oxide are considered types of redoximorphic concentrations.

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter. Plant and animal residue in the soil in various stages of decomposition.

Outwash plain. A landform of mainly sandy or coarse textured material of glaciofluvial origin. An outwash plain is commonly smooth; where pitted, it generally is low in relief.

Pan. A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan, fragipan, claypan, plowpan,* and *traffic pan*.

Parent material. The unconsolidated organic and mineral material in which soil forms.

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedon. The smallest volume that can be called “a soil.” A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Percs slowly (in tables). The slow movement of water through the soil adversely affects the specified use.

Permeability. The quality of the soil that enables water or air to move downward through the profile. The rate at which a saturated soil transmits water is accepted as a measure of this quality. In soil physics, the rate is referred to as “saturated hydraulic conductivity,” which is defined in the “Soil Survey Manual.” In line with conventional usage in the engineering profession and with traditional usage in published soil surveys, this rate of flow continues to be expressed as “permeability.” Terms describing permeability, measured in inches per hour, are as follows:

Extremely slow	0.0 to 0.01 inch
Very slow	0.01 to 0.06 inch
Slow	0.06 to 0.2 inch
Moderately slow	0.2 to 0.6 inch
Moderate	0.6 inch to 2.0 inches
Moderately rapid	2.0 to 6.0 inches
Rapid	6.0 to 20 inches
Very rapid	more than 20 inches

Phase, soil. A subdivision of a soil series based on features that affect its use and management, such as slope, stoniness, and flooding.

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Piping (in tables). Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Pitting (in tables). Pits caused by melting around ice. They form on the soil after plant cover is removed.

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from semisolid to plastic.

Plateau. An extensive upland mass with relatively flat summit area that is considerably elevated (more than 100 meters) above adjacent lowlands and separated from them on one or more sides by escarpments.

Playa. The generally dry and nearly level lake plain that occupies the lowest parts of closed depressional areas, such as those on intermontane basin floors. Temporary flooding occurs primarily in response to precipitation and runoff.

Plowpan. A compacted layer formed in the soil directly below the plowed layer.

Ponding. Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

Poor filter (in tables). Because of rapid or very rapid permeability, the soil may not adequately filter effluent from a waste disposal system.

Poorly graded. Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Poor outlets (in tables). Refers to areas where surface or subsurface drainage outlets are difficult or expensive to install.

Potential native plant community. See Climax plant community.

Potential rooting depth (effective rooting depth). Depth to which roots could penetrate if the content of moisture in the soil were adequate. The soil has no properties restricting the penetration of roots to this depth.

Prescribed burning. Deliberately burning an area for specific management purposes, under the appropriate conditions of weather and soil moisture and at the proper time of day.

Productivity, soil. The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Proper grazing use. Grazing at an intensity that maintains enough cover to protect the soil and maintain or improve the quantity and quality of the desirable vegetation. This practice increases the vigor and reproduction capacity of the key plants and promotes the accumulation of litter and mulch necessary to conserve soil and water.

Range condition. The present composition of the plant community on a range site in relation to the potential natural plant community for that site. Range condition is expressed as excellent, good, fair, or poor on the basis of how much the present plant community has departed from the potential.

Rangeland. Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Range site. An area of rangeland where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. A range site is the product of all the environmental factors responsible for its development. It is typified by an association of species that differ from those on other range sites in kind or proportion of species or total production.

Reaction, soil. A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degrees of acidity or alkalinity, expressed as pH values, are:

Ultra acid	less than 3.5
Extremely acid	3.5 to 4.4
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Moderately acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Redoximorphic concentrations. Nodules, concretions, soft masses, pore linings, and other features resulting from the accumulation of iron or manganese oxide. An indication of chemical reduction and oxidation resulting from saturation.

Redoximorphic depletions. Low-chroma zones from which iron and manganese oxide or a combination of iron and manganese oxide and clay has been removed. These zones are indications of the chemical reduction of iron resulting from saturation.

Redoximorphic features. Redoximorphic concentrations, redoximorphic depletions, reduced matrices, a positive reaction to alpha,alpha-dipyridyl, and other features indicating the chemical reduction and oxidation of iron and manganese compounds resulting from saturation.

Reduced matrix. A soil matrix that has low chroma in situ because of chemically reduced iron (Fe II). The chemical reduction results from nearly continuous wetness. The matrix undergoes a change in hue or chroma within 30 minutes after exposure to air as the iron is oxidized (Fe III). A type of redoximorphic feature.

Relief. The elevations or inequalities of a land surface, considered collectively.

Residuum (residual soil material). Unconsolidated, weathered or partly weathered mineral material that accumulated as consolidated rock disintegrated in place.

Rill. A steep-sided channel resulting from accelerated erosion. A rill generally is a few inches deep and not wide enough to be an obstacle to farm machinery.

Road cut. A sloping surface produced by mechanical means during road construction. It is commonly on the uphill side of the road.

Rock fragments. Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Rooting depth (in tables). Shallow root zone. The soil is shallow over a layer that greatly restricts roots.

Root zone. The part of the soil that can be penetrated by plant roots.

Runoff. The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sandstone. Sedimentary rock containing dominantly sand-sized particles.

Saprolite. Unconsolidated residual material underlying the soil and grading to hard bedrock below.

Saturation. Wetness characterized by zero or positive pressure of the soil water. Under conditions of saturation, the water will flow from the soil matrix into an unlined auger hole.

Scarification. The act of abrading, scratching, loosening, crushing, or modifying the surface to increase water absorption or to provide a more tillable soil.

Sedimentary rock. Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Shrink-swell (in tables). The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silica. A combination of silicon and oxygen. The mineral form is called quartz.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Siltstone. Sedimentary rock made up of dominantly silt-sized particles.

Similar soils. Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

Site index. A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75.

Slickensides. Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides may occur at the bases of slip surfaces on the steeper slopes; on faces of blocks, prisms, and columns; and in swelling clayey soils, where there is marked change in moisture content.

Slippage (in tables). Soil mass susceptible to movement downslope when loaded, excavated, or wet.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Slope (in tables). Slope is great enough that special practices are required to ensure satisfactory performance of the soil for a specific use.

Slow intake (in tables). The slow movement of water into the soil.

Small stones (in tables). Rock fragments less than 3 inches (7.6 centimeters) in diameter. Small stones adversely affect the specified use of the soil.

Soft bedrock. Bedrock that can be excavated with trenching machines, backhoes, small rippers, and other equipment commonly used in construction.

Soil. A natural, three-dimensional body at the earth’s surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	less than 0.002

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the material below the solum. The living roots and plant and animal activities are largely confined to the solum.

Stone line. A concentration of coarse fragments in a soil. Generally, it is indicative of an old weathered surface. In a cross section, the line may be one fragment or more thick. It generally overlies material that weathered in place and is overlain by recent sediment of variable thickness.

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded or 15 to 24 inches (38 to 60 centimeters) in length if flat.

Stony. Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Stripcropping. Growing crops in a systematic arrangement of strips or bands that provide vegetative barriers to wind erosion and water erosion.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles adhering without any regular cleavage, as in many hardpans).

Stubble mulch. Stubble or other crop residue left on the soil or partly worked into the soil. It protects the soil from wind erosion and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsoiling. Tilling a soil below normal plow depth, ordinarily to shatter a hardpan or claypan.

Substratum. The part of the soil below the solum.

Subsurface layer. Technically, the E horizon. Generally refers to a leached horizon lighter in color and lower in content of organic matter than the overlying surface layer.

Summer fallow. The tillage of uncropped land during the summer to control weeds and allow storage of moisture in the soil for the growth of a later crop. A practice common in semiarid regions, where annual precipitation is not enough to produce a crop every year. Summer fallow is frequently practiced before planting winter grain.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the “plow layer,” or the “Ap horizon.”

Surface soil. The A, E, AB, and EB horizons, considered collectively. It includes all subdivisions of these horizons.

Talus. Fragments of rock and other soil material accumulated by gravity at the foot of cliffs or steep slopes.

Taxadjuncts. Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior. Soils are recognized as taxadjuncts only when one or more of their characteristics are slightly outside the range defined for the family of the series for which the soils are named.

Terminal moraine. A belt of thick glacial drift that generally marks the termination of important glacial advances.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet. A terrace in a field generally is built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Thin layer (in tables). Otherwise suitable soil material that is too thin for the specified use.

Till plain. An extensive area of nearly level to undulating soils underlain by glacial till.

Tilth, soil. The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toe slope. The outermost inclined surface at the base of a hill; part of a foot slope.

Too arid (in tables). The soil is dry most of the time, and vegetation is difficult to establish.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Toxicity (in tables). Excessive amount of toxic substances, such as sodium or sulfur, that severely hinder establishment of vegetation or severely restrict plant growth.

Trace elements. Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, in soils in extremely small amounts. They are essential to plant growth.

Tuff. A compacted deposit that is 50 percent or more volcanic ash and dust.

Unstable fill (in tables). Risk of caving or sloughing on banks of fill material.

Upland. Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Valley fill. In glaciated regions, material deposited in stream valleys by glacial meltwater. In nonglaciated regions, alluvium deposited by heavily loaded streams.

Variegation. Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Volcaniclastic material. Fragmental material that is dominantly clasts of volcanic origin. It includes pyroclastic material and epiclastic deposits derived from volcanic sources as a result of mass movement and stream erosion. Examples are welded tuff and volcanic breccia.

Water bars. Smooth, shallow ditches or depressional areas that are excavated at an angle across a sloping road. They are used to reduce the downward velocity of water and divert it off and away from the road surface. Water bars can easily be driven over if constructed properly.

Weathering. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

Well graded. Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Wilting point (or permanent wilting point). The moisture content of soil, on an ovendry basis, at which a plant (specifically a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

Windthrow. The uprooting and tipping over of trees by the wind.

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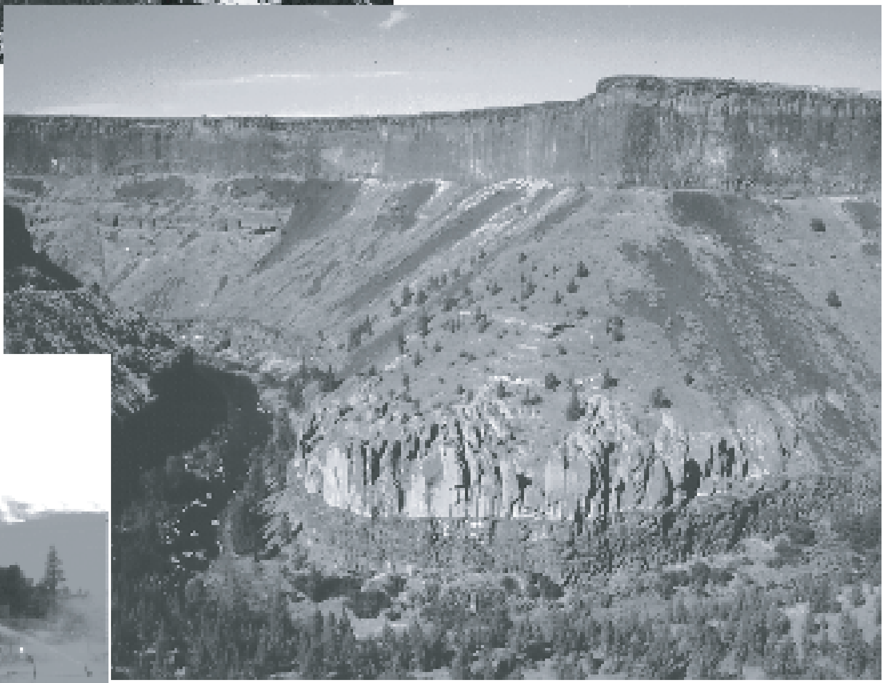
Ground-Water Hydrology of the Upper Deschutes Basin, Oregon



U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
Water-Resources Investigations
Report 00-4162

Prepared in cooperation with
OREGON WATER RESOURCES DEPARTMENT;
CITIES OF BEND, REDMOND, AND SISTERS;
DESCHUTES AND JEFFERSON COUNTIES;
THE CONFEDERATED TRIBES OF THE
WARM SPRINGS RESERVATION OF OREGON;
and U.S. ENVIRONMENTAL PROTECTION AGENCY

Cover photographs:
Top: Steelhead Falls on the Deschutes River near Crooked River Ranch, Oregon.
Middle: Crooked River Canyon at Crooked River Ranch, Oregon.
Bottom: North and Middle Sister with a wheel-line irrigation system in the foreground near Sisters, Oregon. (Photographs by Rodney R. Caldwell, U.S. Geological Survey.)

U.S. Department of the Interior
U.S. Geological Survey

Ground-Water Hydrology of the Upper Deschutes Basin, Oregon

BY MARSHALL W. GANNETT, KENNETH E. LITE JR.,
DAVID S. MORGAN, AND CHARLES A. COLLINS

Water-Resources Investigations Report 00–4162

Prepared in cooperation with Oregon Water Resources Department;
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Tables

Conversion Factors and Vertical Datum

Multiply	By	To obtain
inch (in)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
acre	4,047	square meter (m^2)
square mile (mi^2)	2.590	square kilometer (km^2)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
inches per year (in/yr)	0.0254	meters per year (m/yr)
feet per day (ft/d)	3.528 × 10-6	meters per second (m/s)
gallon per minute (gal/min)	6.308 × 10-5	cubic meters per second (m^3/s)
square feet per day (ft^2/d)	1.075 × 10-5	square meters per second (m^2/s)
feet per year (ft/yr)	9.659 × 10-9	meters per second (m/s)
acre-feet per year (acre-ft/yr)	3.909 × 10-5	cubic meters per second (m^3/s)
cubic feet per day per square foot (ft^3/d/ft^2)	3.528 × 10-6	cubic meters per second per square meter (m^3/s/m^2)
gallons per day (gal/d)	4.381 × 10-8	cubic meters per second (m^3/s)
feet per second (ft/s)	0.3048	meter per second (m/s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

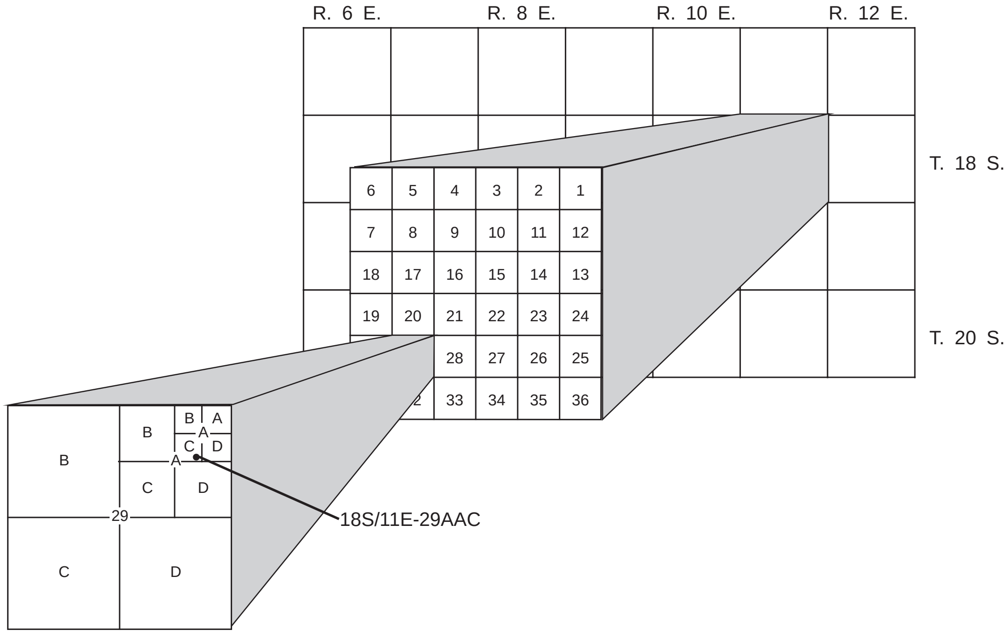
°F=1.8 °C+32

Datums

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Location System

The system used for locating wells, springs, and surface-water sites in this report is based on the rectangular system for subdivision of public land. The State of Oregon is divided into townships of 36 square miles numbered according to their location relative to the east-west Willamette baseline and a north-south Willamette meridian. The position of a township is given by its north-south “Township” position relative to the baseline and its east-west “Range” position relative to the meridian. Each township is divided into 36 one-square-mile (640-acre) sections numbered from 1 to 36. For example, a well designated as 18S/11E-29AAC is located in Township 18 south, Range 11 east, section 29.The letters following the section number correspond to the location within the section; the first letter (A) identifies the quarter section (160 acres); the second letter (A) identifies the quarter-quarter section (40 acres); and the third letter (C) identifies the quarter-quarter-quarter section (10 acres). Therefore, well 29AAC is located in the SW quarter of the NE quarter of the NE quarter of section 29. When more than one designated well occurs in the quarter-quarter-quarter section, a serial number is included.



Well- and spring-location system.

Each well is assigned a unique 8-digit identification number known as the log-id number. The first two digits of the log-id number indicate the county code from the Federal Information Processing Standards (FIPS) code file for the county in which the well exists. The FIPS codes for the counties in the study area are as follows: 13, Crook County; 17, Deschutes County; 31, Jefferson County; and 35, Klamath County. The last 6 digits of the number correspond to the State of Oregon well-log number (a unique number assigned by the Oregon Water Resources Department to the report filed by the well driller).

Mapping Sources:

Base map modified from U.S. Geological Survey 1:500,000 State base map, 1982, with digital data from U.S. Bureau of the Census, TIGER/Line (R), 1990, and U.S. Geological Survey Digital Line Graphs published at 1:100,000.

Publication projection is Lambert Conformal Conic.

Standard parallels 43°00′ and 45°30′, central meridian –120°30′.

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Ground-Water Hydrology of the Upper Deschutes Basin, Oregon

By Marshall W. Gannett, Kenneth E. Lite Jr., David S. Morgan, and Charles A. Collins

Abstract

The upper Deschutes Basin is among the fastest growing regions in Oregon. The rapid population growth has been accompanied by increased demand for water. Surface streams, however, have been administratively closed to additional appropriation for many years, and surface water is not generally available to support new development. Consequently, ground water is being relied upon to satisfy the growth in water demand. Oregon water law requires that the potential effects of ground-water development on streamflow be evaluated when considering applications for new ground-water rights. Prior to this study, hydrologic understanding has been insufficient to quantitatively evaluate the connection between ground water and streamflow, and the behavior of the regional ground-water flow system in general. This report describes the results of a hydrologic investigation undertaken to provide that understanding. The investigation encompasses about 4,500 square miles of the upper Deschutes River drainage basin.

A large proportion of the precipitation in the upper Deschutes Basin falls in the Cascade Range, making it the principal ground-water recharge area for the basin. Water-balance calculations indicate that the average annual rate of ground-water recharge from precipitation is about 3,500 ft^3/s (cubic feet per second). Water-budget calculations indicate that in addition to recharge from precipitation, water enters the ground-water system through interbasin flow. Approximately 800 ft^3/s flows into the Metolius River drainage from the west and about 50 ft^3/s flows into the southeastern part of the study area from the Fort Rock Basin. East of the Cascade Range, there is little or no ground-water recharge from precipitation, but leaking irrigation canals are a significant source of artificial recharge north of Bend. The average annual rate of canal leakage during 1994 was estimated to be about 490 ft^3/s. Ground water flows from the Cascade Range through permeable volcanic rocks eastward out into the basin and then generally northward. About one-half the ground water flowing from the Cascade Range discharges to spring-fed streams along the margins of the range, including the upper Metolius River and its tributaries. The remaining ground water flows through the subsurface, primarily through rocks of the Deschutes Formation, and eventually discharges to streams near the confluence of the Deschutes, Crooked, and Metolius Rivers. Substantial ground-water discharge occurs along the lower 2 miles of Squaw Creek, the Deschutes River between Lower Bridge and Pelton Dam, the lower Crooked River between Osborne Canyon and the mouth, and in Lake Billy Chinook (a reservoir that inundates the confluence of the Deschutes, Crooked, and Metolius Rivers).

The large amount of ground-water discharge in the confluence area is primarily caused by geologic factors. North (downstream) of the confluence area, the upper Deschutes Basin is transected by a broad region of low-permeability rock of the John Day Formation. The Deschutes River flows north across the low-permeability region, but the permeable Deschutes Formation, through which most of the regional ground water flows, ends against this rampart of low-permeability rock. The northward-flowing ground water discharges to the streams in this area because the permeable strata through which it flows terminate, forcing the water to discharge to the surface.Virtually all of the regional ground water in the upper Deschutes Basin discharges to surface streams south of the area where the Deschutes River enters this low-permeability terrane, at roughly the location of Pelton Dam.

The effects of ground-water withdrawal on streamflow cannot presently be measured because of measurement error and the large amount of natural variability in ground-water discharge. The summer streamflow near Madras, which is made up largely of ground-water discharge, is approximately 4,000 ft^3/s. Estimated consumptive ground-water use in the basin is about 30 ft^3/s, which is well within the range of the expected streamflow measurement error. The natural variation in ground-water discharge upstream of Madras due to climate cycles is on the order of 1,000 ft^3/s. This amount of natural variation masks the effects of present ground-water use. Even though the effects of ground-water use on streamflow cannot be measured, geologic and hydrologic analysis indicate that they are present.

Ground-water-level fluctuations in the upper Deschutes Basin are driven primarily by decadal climate cycles. Decadal water-level fluctuations exceeding 20 ft (feet) have been observed in wells at widespread locations near the margin of the Cascade Range. The magnitude of these fluctuations diminishes toward the east, with increasing distance from the Cascade Range. Annual water-level fluctuations of a few feet are common in areas of leaking irrigation canals, with larger fluctuations observed in some wells very close to canals. Annual water-level fluctuations of up to 3 ft due to ground-water pumping were observed locally. No long-term water-level declines attributable to pumping were found in the upper Deschutes Basin.

The effects of stresses to the ground-water system are diffused and attenuated with distance. This phenomenon is shown by the regional response to the end of a prolonged drought and the shift to wetter-than-normal conditions starting in 1996. Ground-water levels in the Cascade Range, the locus of ground-water recharge, stopped declining and started rising during the winter of 1996. In contrast, water levels in the Redmond area, 30 miles east of the Cascade Range, did not start to rise again until late 1997 or 1998. The full effects of stresses to the ground-water system, including pumping, may take several years to propagate across the basin.

Ground-water discharge fluctuations were analyzed using stream-gage records. Ground-water discharge from springs and seeps estimated from stream-gage records shows climate-driven decadal fluctuations following the same pattern as the water-level fluctuations. Data from 1962 to 1997 show decadal-scale variations of 22 to 74 percent in ground-water discharge along major streams that have more than 100 ft^3/s of ground-water inflow.

Introduction

Background and Study Objectives

The upper Deschutes Basin is presently one of the fastest growing population centers in the State of Oregon. The number of people in Deschutes County, the most populous county in the basin, more than tripled between 1970 and 1998 (State of Oregon, 1999). Approximately 140,000 people lived in the upper Deschutes Basin as of 1998. Growth in the region is expected to continue, and residents and government agencies are concerned about water supplies for the burgeoning population and the consequences of increased development for existing water users. Surface-water resources in the area have been closed by the State of Oregon to additional appropriation for many years. Therefore, virtually all new development in the region must rely on ground water as a source of water. Prior to this study, very little quantitative information was available on the ground-water hydrology of the basin. This lack of information made ground-water resource management decisions difficult and was generally a cause for concern.

To fill this information void, the U.S. Geological Survey (USGS) began a cooperative study in 1993 with the Oregon Water Resources Department (OWRD), the cities of Bend, Redmond, and Sisters, Deschutes and Jefferson Counties, The Confederated Tribes of the Warm Springs Reservation of Oregon, and the U.S. Environmental Protection Agency. The objectives of this study were to provide a quantitative assessment of the regional ground-water system and provide the understanding and analytical tools for State and local government agencies, hydrologists, and local residents to make resource management decisions. This report is one in a series that presents the results of the upper Deschutes Basin ground-water study.

Purpose and Scope

The purpose of this report is to provide a comprehensive quantitative description of regional ground-water flow in the upper Deschutes Basin. The report provides an analysis of the data compiled or collected during the study, and presents a description of the regional ground-water hydrology based on that analysis.

The results of the study presented herein are based on both preexisting information and new data. Preexisting information included regional-scale maps of geology, topography, soils, vegetation, and precipitation. In addition, streamflow data were available for numerous sites for periods of time since the early 1900s. Data were also available from several weather stations that operate in the study area. In addition, surface-water diversion records were available for all major irrigation canals. Data described above were augmented by data from numerous reports and studies. Hydrologic data collected for this study included gain/loss measurements for several streams, and geologic and hydraulic-head data from about 1,500 wells that were precisely located in the field. Geophysical, lithologic, and hydrographic data were collected from a subset of these wells. Wells are unevenly distributed in the area and occur mostly in areas of privately owned land. There are few well data from the large tracts of public land that cover most of the study area. Therefore, there are large regions of the Cascade Range, Newberry Volcano, and the High Lava Plains where subsurface hydrologic information is sparse.

This study is regional in scope. It is intended to provide the most complete assessment possible of the regional ground-water hydrology of the upper Deschutes Basin given the data that were available or that could be collected within the resources of the project. This work is not intended to describe details of ground-water flow at local scales; however, it will provide a sound framework for local-scale investigations.

Study Area

The upper Deschutes Basin study area encompasses approximately 4,500 mi^2 (square miles) of the Deschutes River drainage basin in central Oregon (fig. 1). The area is drained by the Deschutes River and its major tributaries: the Little Deschutes River, Tumalo Creek, Squaw Creek, and the Metolius River from the west, and the Crooked River from the east. Land-surface elevation ranges from less than 1,300 ft near Gateway in the northern part of the study area to more than 10,000 ft above sea level in the Cascade Range.

The study-area boundaries were chosen to coincide as much as possible with natural hydrologic boundaries across which ground-water flow can be reasonably estimated or assumed to be negligible. The study area is bounded on the north by Jefferson Creek, the Metolius River, the Deschutes River, and Trout Creek; on the east by the generalized contact between the Deschutes Formation and the older, much less permeable John Day Formation; on the south by the drainage divides between the Deschutes Basin and the Fort Rock and Klamath Basins; and on the west by the Cascade Range crest.

The study area includes the major population centers in the basin, where ground-water development is most intense and resource management questions are most urgent. The major communities include Bend, Redmond, Sisters, Madras, Prineville, and La Pine. Principal industries in the region are agriculture, forest products, tourism, and service industries.

Sixty-six percent of the 4,500 mi^2 upper Deschutes Basin is publicly owned (fig. 2). Approximately 2,230 mi^2 are under the jurisdiction of the U.S. Forest Service, 730 mi^2 are under the jurisdiction of the Bureau of Land Management, and about 20 mi^2 are under the stewardship of State or County agencies. The remaining 1,520 mi^2 are in private ownership.

The highest elevations in the upper Deschutes Basin are in the western and southern parts. These regions are covered by coniferous forests, most of which have been managed for timber production. The remaining parts of the basin, which are at lower elevations, are more arid and, where not cultivated, are dominated by grassland, sagebrush, and juniper. Most of the non-forest-related agriculture occurs in the central and northern parts of the upper Deschutes Basin.

There are approximately 164,000 acres (256 mi^2) of irrigated agricultural land in the study area. The largest source of irrigation water is the Deschutes River. Most water is diverted from the Deschutes River near Bend and distributed to areas to the north through several hundred miles of canals. Smaller amounts of irrigation water are diverted from Tumalo and Squaw Creeks, the Crooked River, and Ochoco Creek.

The climate in the Deschutes Basin is controlled primarily by air masses that move eastward from the Pacific Ocean, across western Oregon, and into central Oregon. The climate is moderate with cool, wet winters and warm, dry summers. Orographic processes result in large amounts of precipitation in the Cascade Range in the western part of the basin, with precipitation locally exceeding 200 in/yr (inches per year), mostly as snow, during the winter (Taylor, 1993). Precipitation rates diminish rapidly toward the east to less than 10 in/yr in the central part of the basin (fig. 3). Temperatures also vary across the basin. Records from the Oregon Climate Service show mean daily minimum and maximum temperatures at Santiam Pass in the Cascade Range (period of record 1961–85) range from 21 and 34°F (degrees Fahrenheit) in January to 43 and 73°F in July (Oregon Climate Service, 1999). Conditions are warmer at lower elevations in the central part of the basin. The mean daily minimum and maximum temperatures in Bend (period of record 1961 to 1999) range from 22 and 42°F in January to 45 and 81°F in July (Oregon Climate Service, 1999). Climate in the Deschutes Basin exhibits year-to-year and longer-term variability. This variability generally parallels regional trends in the Pacific Northwest that have been correlated with large-scale ocean-atmosphere climate variability patterns in the Pacific Basin such as the El Niño/Southern Oscillation (Redmond and Koch, 1991) and the Pacific Decadal Oscillation (Mantua and others, 1997).

Approach

The approach to this study consisted of five major elements: (1) reviewing existing geologic and hydrologic maps and literature and conceptual models of the regional flow system, (2) inventorying and field-locating wells for subsurface geological and hydraulic-head information, (3) compiling and collecting data to estimate the amounts and distribution of various components of the hydrologic budget, (4) compiling and collecting water-level fluctuation information to evaluate the dynamics of regional ground-water flow and assess the state of the system, and (5) developing a computer model to simulate the ground-water flow system. This report addresses the first four of these elements.

At the onset of this investigation there were no published reports on the quantitative regional ground-water hydrology of the basin. The only regional-scale reports prior to this study were an unpublished descriptive report written for the Oregon State Engineer (Sceva, 1960) and an assessment of the potential effects of disposal wells in the basin (Sceva, 1968). All other ground-water reports and studies were restricted to smaller geographic areas. Sceva's works presented a conceptual model of regional ground-water flow in the basin that has been largely corroborated by this study. Although no single geologic map encompassed the entire study area at a scale larger than 1:500,000, the study area was largely covered by a montage of maps at scales ranging from 1:100,000 to 1:24,000.

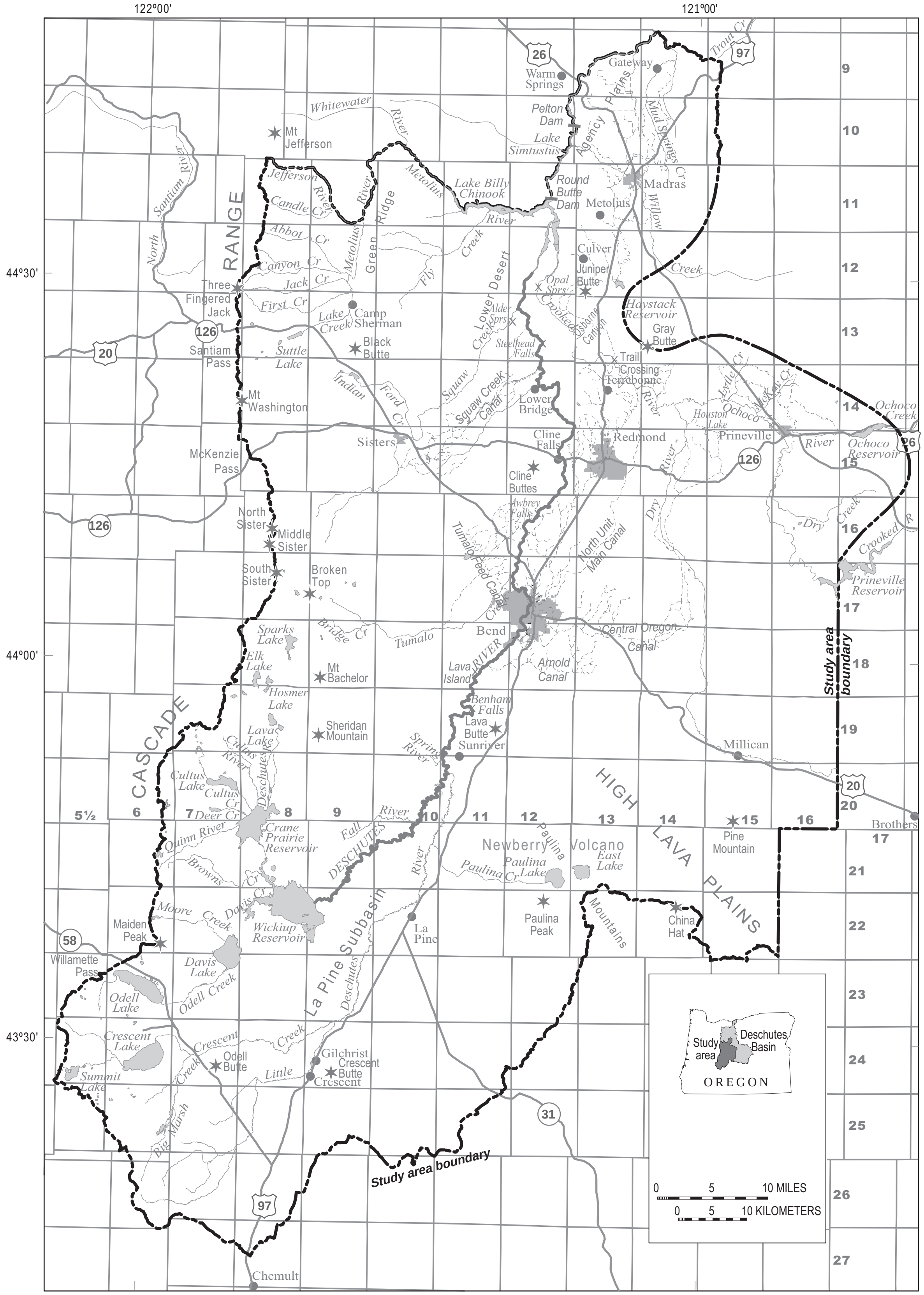

Figure 1. Location of the upper Deschutes Basin, Oregon, and major geographic and cultural features.

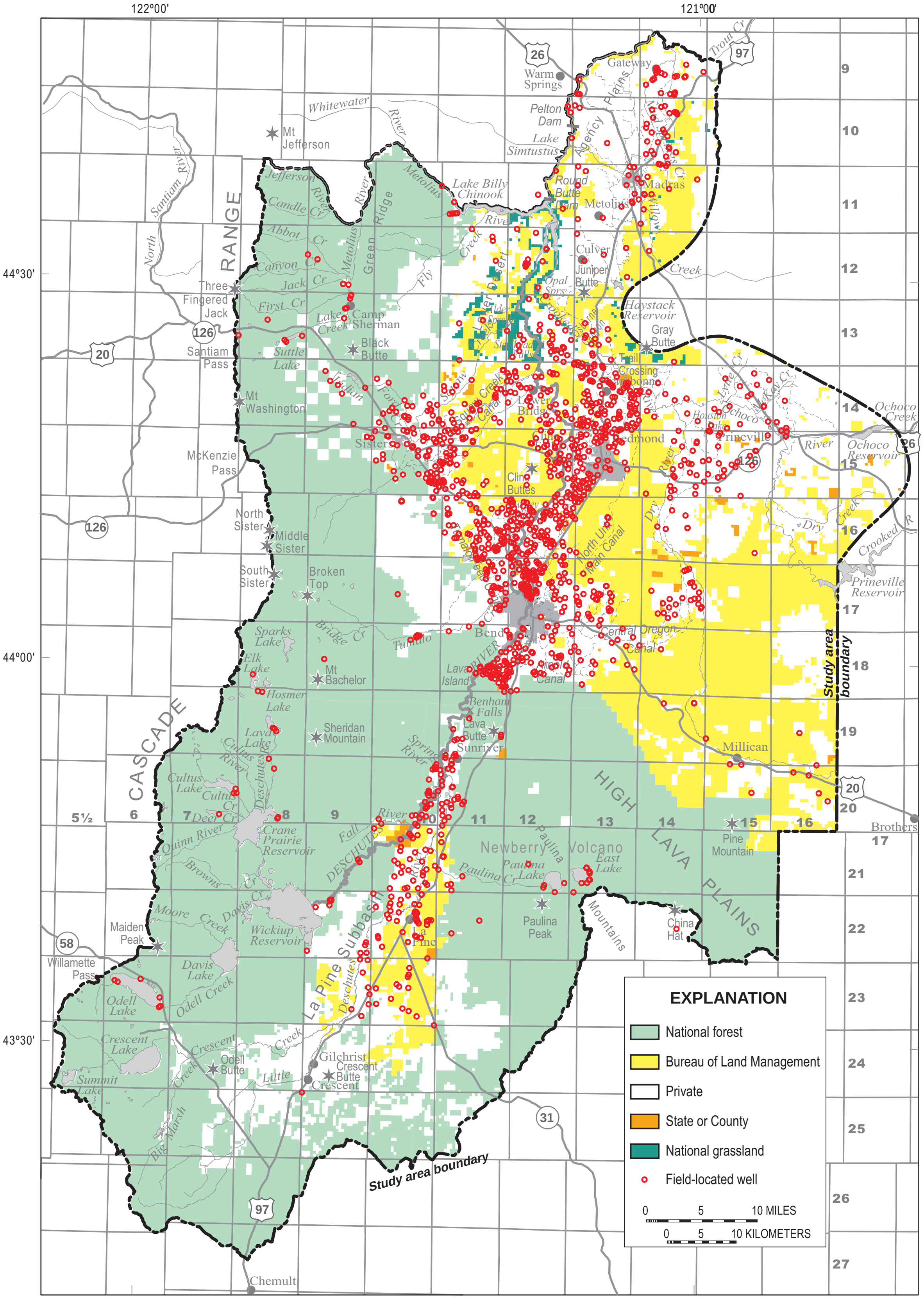

Figure 2. Location of field-located wells and land ownership in the upper Deschutes Basin, Oregon.

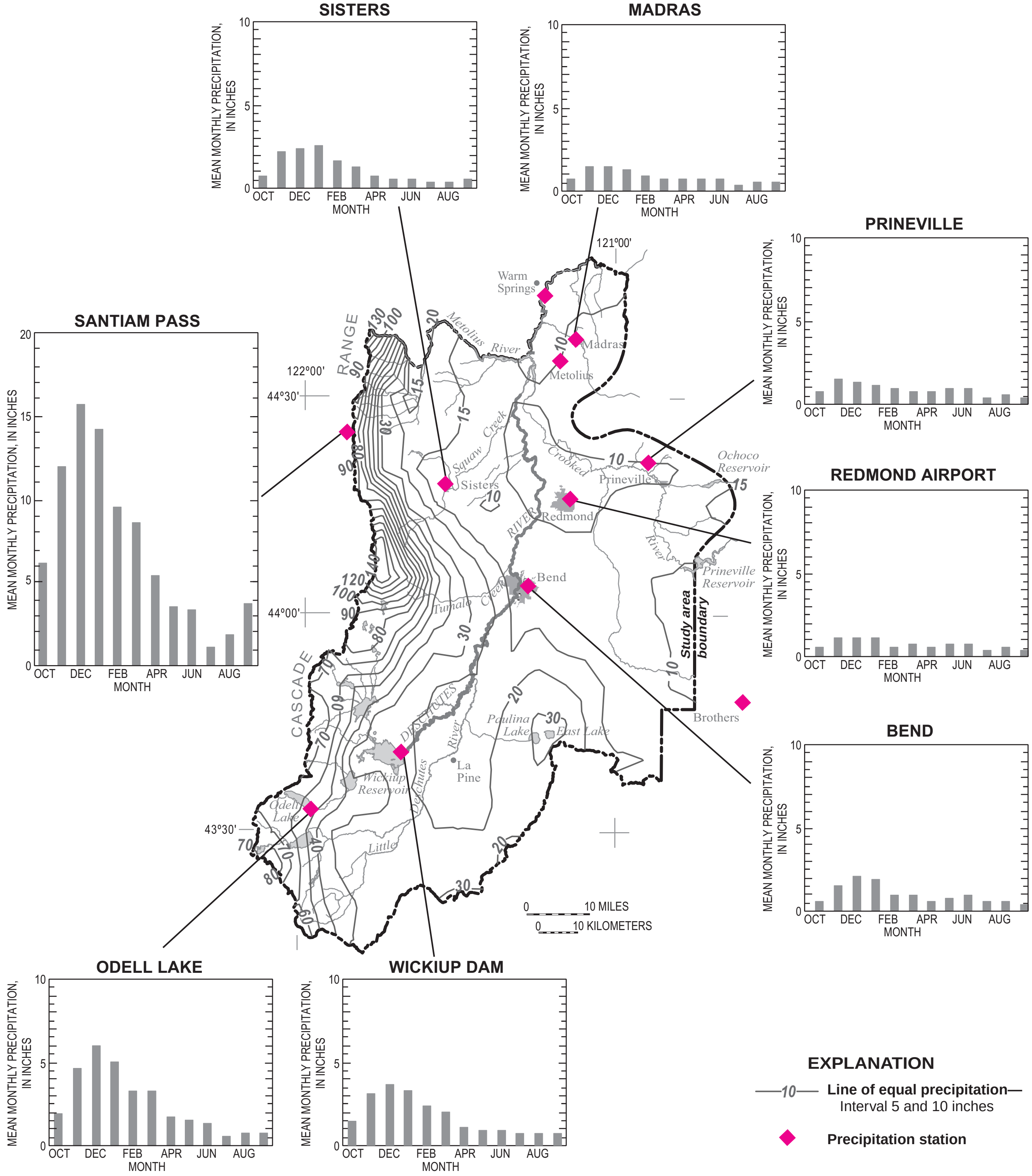

Figure 3. Lines of equal precipitation and graphs of mean monthly precipitation for selected precipitation stations in the upper Deschutes Basin, Oregon.

This study benefited from the inventory and field location of about 700 wells by the USGS in the late 1970s as part of a study that was later terminated for lack of funding. In addition, geophysical logs and periodic water-level measurements existed for a subset of those wells. To augment the 700 wells field located at the start of this investigation, an additional 800 wells were inventoried and field located. The geographic distribution of these 1,500 field-located wells (fig. 2) mirrors the distribution of wells in the basin in general. The highest density of wells occurs on private land. Water levels were measured in located wells whenever possible. Field-located wells provided information on hydraulic-head distribution and subsurface geology. Approximately 35 wells were geophysically logged and drill cuttings were collected for approximately 70 wells. One-hour specific-capacity tests were available for most wells and aquifer tests were conducted on four wells to provide additional information on hydraulic characteristics.

Water-level data from field-located wells and elevations of major springs and gaining streams were used to map hydraulic-head distribution in the region. The resulting distribution map was the basic source of information regarding the horizontal and vertical directions of ground-water flow.

Major components of the hydrologic budget were either measured or estimated. Recharge from natural precipitation was estimated by a daily mass-balance approach using the Deep Percolation Model (DPM) of Bauer and Vaccaro (1987). Recharge from canal leakage was estimated from surface-water diversion records and estimates of farm deliveries, in combination with canal seepage studies conducted by the Bureau of Reclamation (BOR). Farm deliveries and on-farm losses were derived from consumptive-use and irrigation-efficiency estimates. On-farm consumptive use was estimated from crop information derived from LANDSAT images and crop-water-use estimates from BOR AgriMet stations in the basin.

The rate and distribution of ground-water discharge to streams and springs throughout the study area were estimated using data from active and historic stream gages, gain/loss studies conducted by OWRD Central Region staff, and miscellaneous published streamflow measurements. The rate and distribution of ground-water pumping was estimated for public supply and for irrigation uses. Public-supply pumping was derived from measurements or estimates supplied by the municipalities and other public water suppliers. Irrigation pumping was estimated using information from the OWRD Water-Rights Information System (WRIS) in combination with on-farm consumptive-use estimates derived in the manner described above. Pumping by private domestic wells was estimated using well-log records and population statistics.

The dynamics of the ground-water flow system, both at a regional and local scale, were evaluated by analyzing ground-water-level fluctuations in response to both long- and short-term hydrologic phenomena such as variations in climate, individual storms, canal operation, and pumping. Periodic water-level measurements were compiled from historic data and collected from about 100 wells. The frequency of measurements and the duration of records for wells varied considerably. There were about 90 wells with quarterly water-level measurements spanning periods ranging from a few years to over 50 years. In addition, there are 16 wells in which water levels were recorded every 2 hours for periods ranging from a few months to over 4 years (Caldwell and Truini, 1997).

The chemistry of selected wells, springs, and canals in the study area was analyzed and interpreted by Caldwell (1998). This analysis provided additional insights into the regional ground-water flow system and into the interaction of ground water and surface water, including irrigation canals.

Acknowledgments

The authors gratefully acknowledge the support of the residents of the upper Deschutes Basin through-out this investigation. Particular thanks go to the hundreds of landowners who allowed access to their wells for water-level monitoring and sampling. The Public Works staff of the cities of Bend, Redmond, Sisters, and Madras were extremely helpful in providing access to their water systems as well as information on water use and disposal wells. Private water companies in the basin were also helpful, but particular thanks goes to Avion Water Company, Black Butte Ranch Corporation, Deschutes Valley Water District, and Juniper Utility for access to their wells for monitoring, testing, and sampling. Information on diversions and water use provided by the many irrigation districts in the basin was extremely helpful and is greatly appreciated. There are several individuals who have particular knowledge of certain aspects of geology or water in the basin, and who freely shared ideas and insights with the authors. This group includes (alphabetically) Larry Chitwood, Rick Conrey, Mark Ferns, Kyle Gorman, Bob Main, Dave Sherrod, and Jan Wick. Larry Chitwood provided a thoughtful and thorough review of this report. Lastly, special thanks go to Susan Prowell with the city of Bend, who handled all the logistics for years of quarterly meetings, and to all the people who showed their interest and support by attending them.

Geologic Framework

The storage and flow of ground water are controlled to a large extent by geology. The principle geologic factors that influence ground water are the porosity and permeability of the rock or sediment through which it flows. Porosity, in general terms, is the proportion of a rock or deposit that consists of open space. In a gravel deposit, this would be the proportion of the volume of the deposit represented by the space between the individual pebbles and cobbles. Permeability is a measure of the resistance to the movement of water through the rock or deposit. Deposits with large interconnected open spaces, such as gravel, have little resistance to ground-water flow and are therefore considered highly permeable. Rocks with few, very small, or poorly connected open spaces offer considerable resistance to ground-water flow and, therefore, have low permeability. The hydraulic characteristics of geologic materials vary between rock types and within particular rock types. For example, in sedimentary deposits the permeability is a function of grain size and the range of grain sizes (the degree of sorting). Coarse, well-sorted gravel has much higher permeability than fine, silty sand deposits. The permeability of lava flows can also vary markedly depending on the degree of fracturing. The highly fractured, rubbly zones at the tops and bottoms of lava flows and in interflow zones are often highly permeable, while the dense interior parts of lava flows can have very low permeability. Weathering and secondary mineralization, which are often a function of the age of the rock, can strongly influence permeability. Sedimentary deposits or lava flows in which the original open spaces have been infilled with secondary minerals can have very low permeability.

Geologic properties that influence the movement of ground water within a flow system can also define the boundaries of the system. Terranes consisting of predominantly low-permeability materials can form the boundaries of a regional flow system.

This section briefly describes the geologic framework of the regional ground-water flow system in the upper Deschutes Basin, including a brief description of the major geologic units, geologic structure, and the geologic factors controlling the flow-system boundaries.

Geologic Controls on Regional Ground-Water Flow

The upper Deschutes Basin has been a region of volcanic activity for at least 35 million years (Sherrod and others, in press), resulting in complex assemblages of volcanic vents and lava flows, pyroclastic deposits, and volcanically derived sedimentary deposits (fig. 4). Volcanic processes have created many of the present-day landforms in the basin. Glaciation and stream processes have subsequently modified the landscape in many places.

EXPLANATION

Geologic unit present at land surface

Qalg	Quaternary alluvium and glacial deposits; Quaternary to late Tertiary landslide deposits
Qs	Quaternary sediments and sedimentary rocks, undivided
Qp	Quaternary pyroclastic deposits
QTba	Quaternary to late Tertiary basaltic to andesitic lava
QTrd	Quaternary and late Tertiary rhyolitic to dacitic lava
QTv	Quaternary and late Tertiary vent deposits, Deschutes Formation and age-equivalent deposits
Tds	Late Tertiary sediments and sedimentary rocks, undivided, mostly of the Deschutes Formation
Tba	Tertiary basaltic to andesitic lava
Trd	Tertiary rhyolitic to dacitic lava
Tp	Tertiary pyroclastic deposits
Tv	Tertiary vent deposits
Tpb	Prineville basalt
Tjd	Early Tertiary volcanic deposits, mainly the John Day Formation
——— - - - ······	Geologic fault, dashed where inferred, dotted where concealed
- - - -	Outline of La Pine and Shukash structural basins, inferred from gravity data

NOTE: Geology generalized from:
MacLeod and Sherrod, 1992;
MacLeod and others, 1995;
Sherrod, 1991;
Sherrod and Smith, 2000;
Sherrod and others, in press;
Smith, 1987; Smith and Hayman, 1987;
Swanson, 1969, and
Walker and others, 1967.

Shukash and La Pine outline from Richard Couch,
Oregon State University, personal commun., 1996.

0 5 10 MILES
0 5 10 KILOMETERS

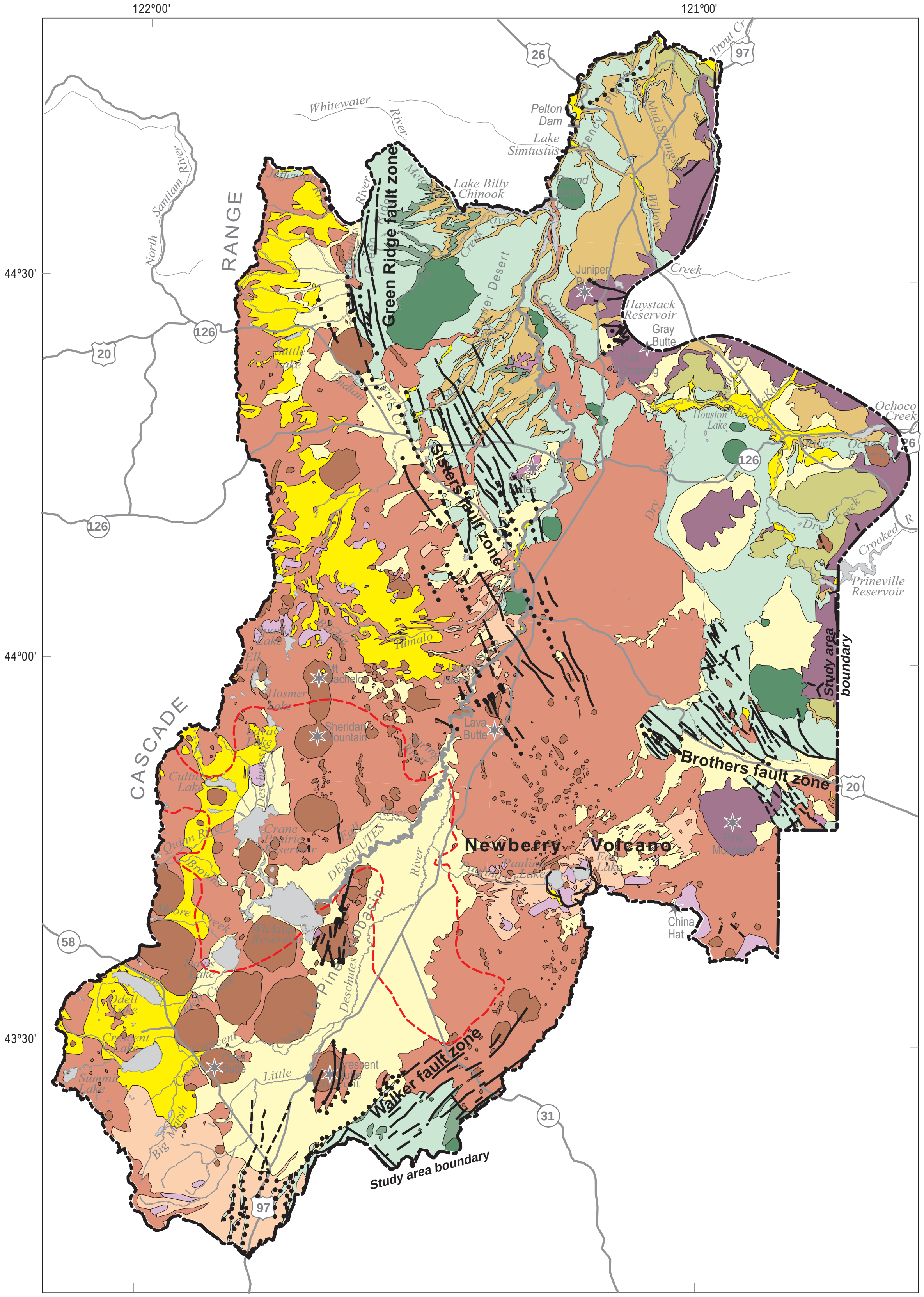

Figure 4. Generalized geology of the upper Deschutes Basin, Oregon.

Most of the upper Deschutes Basin falls within two major geologic provinces, the Cascade Range and the Basin and Range Province (Orr and others, 1992). The processes that have operated in these provinces have overlapped and interacted in much of the upper Deschutes Basin. The Cascade Range is a north-south trending zone of compositionally diverse volcanic eruptive centers and their deposits extending from northern California to southern British Columbia. Prominent among the eruptive centers in the Deschutes Basin are large stratovolcanoes such as North, Middle, and South Sister, and Mount Jefferson, all of which exceed 10,000 ft in elevation. The Cascade Range is primarily a constructional feature, but its growth has been accompanied, at least in places, by subsidence of the range into a north-south trending graben (Allen, 1966). Green Ridge is the eastern escarpment of one of the graben-bounding faults. The Basin and Range Province is a region of crustal extension and is characterized by subparallel fault-bounded down-dropped basins separated by fault-block ranges. Individual basins and intervening ranges are typically 10 to 20 miles across. The Basin and Range Province, which encompasses much of the interior of the Western United States, extends from central Oregon south through Nevada and western Utah, and into the southern parts of California, Arizona, and New Mexico. Although the Basin and Range Province is primarily structural, faulting has been accompanied by widespread volcanism. The major stratigraphic units in the upper Deschutes Basin are described below in approximate order of their age.

The oldest rocks in the upper Deschutes Basin study area (unit Tjd in fig. 4) are part of the late Eocene to early Miocene John Day Formation and consist primarily of rhyolitic ash-flow tuffs, lava flows, tuffaceous sedimentary rocks, and vent deposits. The John Day Formation ranges in age from 22 to 39 million years and is as much as 4,000 ft thick (Smith and others, 1998). Rocks of the John Day Formation have very low permeability because the tuffaceous materials are mostly devitrified (changed to clays and other minerals) and lava flows are weathered and contain abundant secondary minerals. Because of the low permeability, ground water does not easily move through the John Day Formation, and the unit acts as a barrier to regional ground-water flow. The John Day Formation constitutes the eastern and northern boundary of the regional ground-water flow system. The John Day Formation, or equivalent rocks, are presumed to underlie much of the upper Deschutes Basin and are considered the lower boundary of the regional flow system throughout much of the study area.

The Prineville basalt (unit Tpb in figure 4) overlies the John Day Formation in the northeastern part of the study area. Radiometric techniques indicate that the Prineville basalt is 15.7 million years old (Smith, 1986). The Prineville basalt, which is up to 700 ft thick, is locally fractured, contains permeable interflow zones, and is locally an important aquifer.

The Deschutes Formation, which overlies the Prineville basalt, consists of a variety of materials deposited in an alluvial basin east of the Cascade Range, including lava flows, ignimbrites, fallout tephra, debris flows, hyperconcentrated flood deposits, and alluvium. Most of the deposits originated in the Cascade Range and were shed eastward into the basin, but some originated from intrabasin eruptive centers or were eroded from older (John Day Formation) uplands to the east. The Deschutes Formation was deposited in a rapidly filling basin with a constantly changing drainage system between about 4.0 and 7.5 million years ago (Smith, 1986). Deposition of many units within the formation was restricted to canyons and other short-lived topographic lows. Consequently, individual strata within the Deschutes Formation typically have limited geographic distribution resulting in a heterogeneous sequence. Most of the areas mapped as Tds, Tba, Tp, and Tv in figure 4 are generally recognized as part of the Deschutes Formation. Some areas so mapped in southern part of figure 4 are not generally considered part of the Deschutes Formation, but are composed of rocks similar in composition and age to the Deschutes Formation, and likely have similar hydrologic characteristics.

Strata within the Deschutes Formation were deposited in three main depositional environments (Smith, 1986). The westernmost depositional environment was a broad plain adjacent to the Cascade Range, on which a variety of materials were deposited, including flood and debris-flow deposits, ignimbrites, fallout tephra, and lava flows. The ancestral Deschutes River was another depositional environment, occurring along the eastern margin of the alluvial plain. Deposits in the ancestral Deschutes River environment include well-sorted conglomerates and coarse sandstone, fine sandstone, mudstone, and intracanyon lava flows. A third depositional environment existed along the inactive eastern margin of the basin. Here, material eroded from the highland of older rock to the east (mostly John Day Formation) was redeposited, resulting in beds of poorly sorted angular gravel and sand, reworked pyroclastic debris, and fine-grained sediment.

The Deschutes Formation is the principal aquifer unit in the upper Deschutes Basin. The unit ranges in thickness from zero where it contacts the underlying John Day Formation or Prineville basalt to over 2,000 ft at its westernmost exposure at Green Ridge. Permeable zones occur throughout the Deschutes Formation. The lava flows, vent deposits, and sand and gravel layers in the Cascade Range-adjacent alluvial plain facies and the ancestral Deschutes River facies are locally highly permeable. Two sequences of lava flows in the Deschutes Formation, the Opal Springs basalt, which is up to 120 ft thick, and the Pelton basalt, which may locally exceed 400 ft in thickness, are notable aquifers and locally discharge large amounts of water where exposed in the canyons of the

Deschutes and Crooked Rivers. The inactive margin facies is less permeable because of poor sorting and a high degree of weathering.

Rhyolite and rhyodacite domes (unit Trd in figure 4) occur in the north-central part of the study area and are locally interbedded with the Deschutes Formation. These materials form Cline Buttes and also crop out in the area between the Deschutes River and Squaw Creek north of Lower Bridge. These rocks are locally highly fractured and permeable. Numerous springs discharge from permeable zones in this unit where it is exposed in the canyon of the Deschutes River near Steelhead Falls (Ferns and others, 1996).

The Cascade Range and volcanic deposits of similar age elsewhere in the basin overlie the Deschutes Formation and constitute the next major composite stratigraphic unit. These deposits include units Qp, QTba, QTrd, and QTv in figure 4. This composite unit, which is likely several thousand feet thick, is composed of lava flows, domes, vent deposits, pyroclastic deposits, and volcanic sediments. Most are Quaternary in age (younger than 1.6 million years old). This unit includes the entire Cascade Range and Newberry Volcano to the east. Much of this material is highly permeable, especially the upper several hundred feet. Permeability of the unit is greatly reduced at depth beneath the Cascade Range, however, due to hydrothermal alteration and secondary mineralization (Blackwell and others, 1990; Blackwell, 1992; Ingebritsen and others, 1992). Temperature gradient data (Swanberg and others, 1988) and hydrothermal mineralization studies (Keith and Barger, 1988, 1999) suggest a similar loss of permeability at depth beneath Newberry Volcano. The top of the region at depth beneath the Cascade Range and Newberry Volcano where permeability is reduced by several orders of magnitude due to hydrothermal mineralization is considered, for the purposes of this study, to be the base of the regional ground-water flow system in these areas.

The Cascade Range and volcanic deposits of similar age are highly permeable at shallow depths. The near-surface deposits are often highly fractured or otherwise porous and largely lack secondary mineralization. The Cascade Range is the principal ground-water recharge area for the upper Deschutes Basin, and these deposits are the principal avenue by which most ground water moves from the recharge area out into the basin. Because there are very few wells in the Cascade Range and on Newberry Volcano, there is little information on the distribution of hydraulic head or subsurface conditions.

The youngest units in the upper Deschutes Basin are Quaternary sedimentary deposits. These deposits include alluvium along modern flood plains, landslide deposits, and glacial drift and outwash (unit Qalg on figure 4). Undifferentiated Quaternary sedimentary deposits resulting from a variety of depositional processes are mapped as Qs in figure 4. Many of the Quaternary sedimentary deposits in the basin are too thin or discontinuous to affect regional ground-water flow. However, glacial deposits, particularly outwash deposits, are sufficiently thick and widespread to be significant. Glacial deposits, generally porous and permeable, are an important source of ground water along the margin of the Cascade Range, for example in the area around the city of Sisters. Alluvial sand and gravel deposits also form an important aquifer in the La Pine subbasin (fig. 4).

Geologic structure, principally faults and fault zones, can influence ground-water flow. Fault zones can act either as barriers to or conduits for ground-water flow, depending on the nature of the material in and between the individual fault planes. Faults most commonly affect ground-water flow by juxtaposing rocks of contrasting permeability or by affecting the patterns of deposition. Structural basins caused by faulting can act as depositional centers for large thicknesses of sediment or lava that may influence regional ground-water flow. Faults do not always influence ground-water flow; there are regions in the upper Deschutes Basin where ground-water flow appears unaffected by the presence of faults.

There are four prominent fault zones in the upper Deschutes Basin (fig. 4). Green Ridge, north of Black Butte, is a prominent north-south trending escarpment caused by faulting along the margin of the Cascade graben. The region to the west of Green Ridge has dropped as much as 3,000 ft (Conrey, 1985). This fault movement has juxtaposed rock materials of contrasting permeability, and subsidence west of the fault system has created a depositional basin for accumulation of volcanic and glacial materials from the Cascade Range. A large amount of ground water discharges to the Metolius River along the western side of the Green Ridge escarpment. It is possible that the ground-water discharge occurs because the Green Ridge fault zone acts as a barrier to the eastward flow of ground water from the Cascade Range. It is also possible that discharge occurs because the western side of the escarpment is a regional topographic low.

The Sisters fault zone is a north-northwest trending zone of normal faults that extends from the north flank of Newberry Volcano to the south end of Green Ridge near Black Butte. Escarpments of some faults along the Sisters fault zone have impounded lava flows from the Cascade Range and prevented flow into lower-elevation areas toward the northeast. Escarpments along the Sisters fault zone also have caused local accumulation of glacial sediments. Although the Sisters fault zone affects the occurrence of shallow ground water by controlling the deposition of glacial sediment, it does not appear to affect ground-water flow at depth.

The Brothers fault zone is a major northwest-trending zone of normal faults that extends from southeastern Oregon to the north flank of Newberry Volcano. Faults along this zone are covered by lava flows from Newberry Volcano and do not appear to offset those flows. The influence of the Brothers fault zone on regional ground-water flow is unknown.

The Walker Rim fault zone is a major northeast-trending zone that extends from Chemult to the south flank of Newberry Volcano. The region to the west has dropped as much as 2,500 ft (feet). The influence of this fault zone on ground-water flow is unknown.

The La Pine and Shukash structural basins (fig. 4) are complex graben structures extending from Newberry Volcano to the crest of the Cascade Range. Much of what is known of these features is from interpretations of gravity data by Couch and Foote (1985, and written commun., 1996). The La Pine graben is a present-day landform, and well data shows that it has accumulated over 1,000 ft of sediment, much of which is fine grained. The Shukash basin, in contrast, has no surface expression, is mostly covered by younger volcanic and glacial deposits, and its existence is inferred largely from gravity data. The sediment thickness at the center of the basin is inferred to be about 2,500 ft. The nature of sediment fill is poorly known, but where exposed or drilled, the sediment in the Shukash basin is similar to that of the La Pine basin. The fine-grained sediment fill in the La Pine and Shukash basins has low permeability. The presence of large springs on the margins of the La Pine and Shukash basins may be due to the juxtaposition of permeable Cascade Range volcanic rocks with the low-permeability basin-fill deposits. The faults bounding both of these grabens are largely obscured by younger volcanic deposits.

Hydraulic Characteristics of Subsurface Materials

As described in the preceding section, geologic materials possess certain hydraulic characteristics that control the movement and storage of ground water. This section describes quantitative terms that represent those characteristics and presents estimates or ranges of values of those terms for various materials in the upper Deschutes Basin. A more thorough discussion of the terms used to describe the hydraulic characteristics of aquifers and aquifer materials can be found in any basic ground-water hydrology text such as Freeze and Cherry (1979), Fetter (1980), or Heath (1983).

The term *permeability* was introduced in the last section as a measure of the resistance to fluid flow offered by a particular rock type. Permeability is an intrinsic property of the rock type, and is independent of the fluid properties. In ground-water studies, the term *hydraulic conductivity* is used more commonly than permeability. The hydraulic conductivity term includes both the properties of the rock (the intrinsic permeability) and the properties of the water, such as viscosity and density. Hydraulic conductivity is defined as the volume of water per unit time that will pass through a unit area of an aquifer material in response to a unit hydraulic-head gradient. Hydraulic conductivity has the units of volume per unit time (such as cubic feet per day) per unit area (such as square feet), which simplifies by division to length per unit time (such as feet per day). Hydraulic-conductivity values for aquifer materials commonly span several orders of magnitude from less than 0.1 ft/d (feet per day) for fine sand and silt to over 1,000 ft/d for well-sorted sand and gravel.

When discussing aquifers instead of rock types, the hydraulic conductivity is often multiplied by the aquifer thickness to derive a term known as *transmissivity*. Transmissivity is defined as the volume of water per unit time that will flow through a unit width of an aquifer perpendicular to the flow direction in response to a unit hydraulic-head gradient. Transmissivity has units of volume per unit time (such as cubic feet per day) per unit aquifer width (such as feet) which simplifies to length squared per unit time (such as square feet per day).

The storage characteristics of an aquifer are described by the storage coefficient. The storage coefficient is defined as the volume of water an aquifer releases from, or takes into, storage per unit area of aquifer per unit change in head. The volume of water has units of length cubed (such as cubic feet), the area has units of length squared (such as square feet), and the head change has units of length (such as feet). Thus, the storage coefficient is dimensionless. Storage coefficients typically span several orders of magnitude from 10-4 for aquifers with overlying confining units, to 0.1 for unconfined aquifers.

Aquifer Tests

The hydraulic characteristics of subsurface materials in the basin have been estimated using data from aquifer tests, some of which were conducted as part of this study, and specific-capacity tests conducted by drillers upon completion of new wells. An aquifer test consists of pumping a well at a constant rate and measuring the change in water level (the drawdown) with time. The data collected allow generation of a curve showing the change in drawdown as a function of time. Similar data are collected after the pumping is stopped, allowing generation of a curve showing the water-level recovery as a function of time. These data are collected not only from the pumped well, but from nearby wells (called observation wells) in which the water level may be affected by the pumping. Analysis of the drawdown and recovery curves in the pumped well and observation wells provides estimates of the transmissivity and storage coefficient of the aquifer.

Four aquifer tests were conducted as part of this study (fig. 5). Each involved pumping a large-capacity public-supply well and observing drawdown and recovery in nearby nonpumped wells. In addition, results from seven aquifer tests conducted by private consultants were available. A common problem encountered in many of the tests was the inability to stress the aquifer sufficiently to induce an interpretable effect in the observation wells. In other words, the aquifer transmissivity is so large in some places that pumping a well in excess of 1,000 gal/min (gallons per minute) may produce only a few hundredths of a foot of drawdown in an observation well just a few hundred feet from the pumped well.

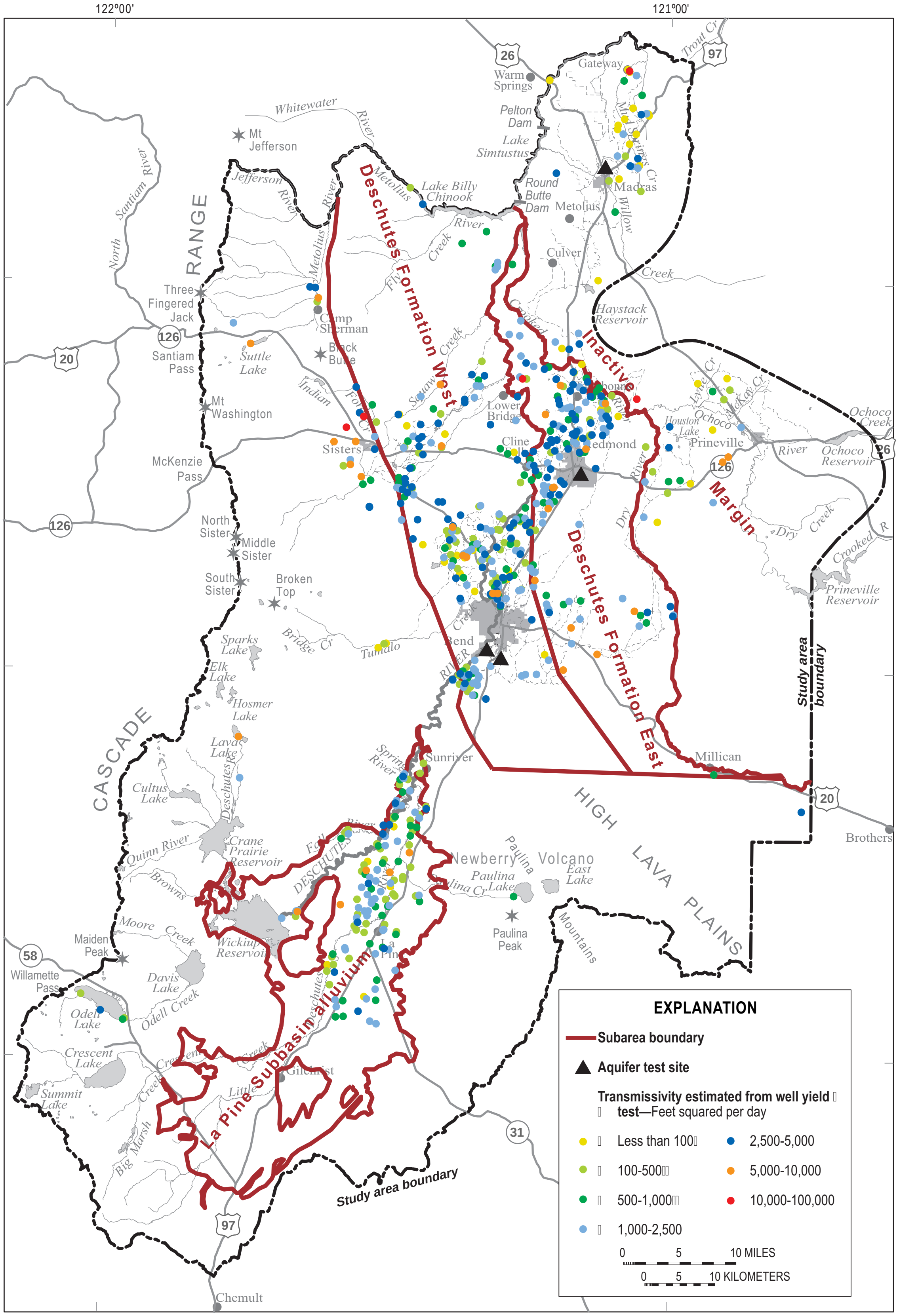

Figure 5. Distribution of transmissivity estimates derived from specific-capacity tests of field-located domestic wells in the upper Deschutes Basin, Oregon, and the locations of aquifer tests conducted for this study.

Aquifer tests were conducted for this study on wells belonging to the cities of Madras, Redmond, andBend, as well as Juniper Utilities, a privately owned water utility. Each of the tests is summarized in table 1 and described in the following paragraphs. The location of the tested wells is shown in figure 5.

The city of Madras test involved pumping City Well No. 2 at 351 gal/min for 3 days and monitoring the response in the pumped well and in an observation well 250 ft from the pumped well. The pumped well produces from a layer of sand and gravel at the base of a sequence of lava flows. The producing sediments are part of the inactive-margin facies of the Deschutes Formation (fig. 5). Both the pumped well and the observation well showed good responses to the pumping, with maximum drawdowns of 36.20 and 17.67 ft respectively. The drawdown and recovery curves were typical of a confined aquifer (Lohman, 1979). The test yielded a transmissivity estimate of 1,700 to 2,500 ft^2/d (square feet per day) and a storage coefficient estimate of 0.0001 to 0.0002.

The city of Redmond test consisted of pumping City Well No. 3 at 1,141 gal/min for 3 days and monitoring the response in the pumped well and an observation well 350 ft from the pumped well. The well produces from a combination of lava flows and sand and gravel layers in the Cascades-adjacent alluvial plain or ancestral Deschutes River facies of the Deschutes Formation. Interpretation of the results of this test was complicated by the very small response in the observation well. Total drawdown in the observation well after 3 days of pumping was only 0.16 ft, which is close to the range of observed pre-test water-level fluctuations caused by external influences such as barometric pressure changes and earth tides. Drawdown in the pumping well (11.67 ft) was dominated by well losses (excessive drawdown in the well bore due to well inefficiency) so only the recovery data from the pumped well was usable. The drawdown and recovery curves resulting from this test were not typical of a confined aquifer. The drawdown followed the typical Theis curve (Lohman, 1979) near the beginning of the test, but later deviated from the curve, indicating that drawdown was less than would be expected for a confined aquifer. The exact cause of this behavior is unknown, but similar behavior is observed in aquifers where drainage of water from overlying strata cause a delayed-yield response (Neuman, 1975). Analysis of the test results yielded a transmissivity estimate of 2.0×10^5 ft^2/d to 3.0×10^5 ft^2/d, and a storage coefficient estimate of 0.05.

The city of Bend test involved pumping one of the wells at the city's Rock Bluff well field south of town at 722 gal/min for a period of 24 hours. This well produces from basaltic lava and cinders of the Deschutes Formation, which is predominantly lava at this location. The response was measured in a nearly identical observation well 210 ft from the pumped well. There was no access to the pumped well for water-level measurements. The drawdown in the observation well was less than 0.06 ft, which is well within the range of water-level fluctuations caused by external influences such as barometric pressure changes and earth tides. The small drawdown due to pumping could not be satisfactorily separated from the water-level fluctuations due to external influences, and no quantitative analysis was possible. The small drawdown in this well, however, suggests a large transmissivity of a magnitude similar to that estimated from the city of Redmond well test.

The fourth aquifer test conducted for this study involved pumping a production well belonging to Juniper Utilities, south of Bend, at 1,300 gal/min for just over 3 hours. This well produces from basaltic lava with minor interbedded cinders which are likely correlative to the Deschutes Formation. Drawdown and recovery were measured in an observation well 35 ft from the pumped well and open to the same water-bearing strata. There was no access for water-level measurements in the pumped well. The draw-down in the observation well, which totaled 1.14 ft after 3 hours, did not follow the Theis curve for a confined aquifer (Lohman, 1979). The drawdown departed from the Theis curve about 7 minutes into the test in a manner indicating that drawdown was less than would be expected for a confined system. After about 50 minutes the water level stabilized and drawdown did not increase for the duration of the test, indicating that the cone of depression encountered a source of recharge equal to the well discharge. The likely source of recharge was leakage from large (hundreds of cubic feet per second) unlined irrigation canals within 3,000 ft of the pumped well. Analysis of recovery data also indicated the aquifer received recharge during the test. The short duration of this test and the atypical response in the observation well precluded a reliable estimation of hydraulic parameters. The relatively small total drawdown in the observation well suggests a large transmissivity.

Results from seven additional aquifer tests conducted by consultants are summarized in table 1. Most of these tests were affected by one or more problems such as insufficient response in observation wells, measurement errors, variable pumping rates, effects of well losses in the pumping well, and recharge effects. Time-drawdown data from five of the tests were not suitable for type-curve analysis, but the tests did allow calculation of the specific capacity of the wells. Specific capacity is a general measure of well performance and is calculated by dividing the rate of pumping by the amount of drawdown and typically has units of gallons per minute per foot of drawdown. Transmissivities were estimated from specific-capacity data using an iterative technique based on the Jacob modified nonequilibrium formula (Ferris and others, 1962, p. 98; Vorhis, 1979).

Table 1. Summary of selected aquifer tests in the upper Deschutes Basin, Oregon.

[OWRD well no., Oregon Water Resources Department well number; gpm, gallons per minute; Analysis method: T, Theis non-equilibrium curve matching; SL, straight-line method; SC, Theis solution using specific-capacity data (Lohman, 1979). Test conducted by: S, study team; C, private consultant. ft2/d, square feet per day; ft, feet; ft/d, feet per day; ---, value not determined; *, time-averaged pumping rate]

Well number	OWRD well no.	Well name	Discharge (gpm)	Duration (hours)	Draw-down	Distance from pumped well	Analysis method	Test conducted by	Transmissivity (ft^2/day)	Storage coefficient	Aquifer material	Open interval length (ft)	Hydraulic conductivity (ft/day)
11S/13E-01BAC1	JEFF0823	City of Madras Well 2	351	72	17.67	250	T, SL	S	1.7×10^3 to 2.5×10^3	0.0001 to 0.0002	Sand & gravel	16	110 to 160
14S/10E-30DDB2	DESC1835	Cascade Meadows	1,000	4.5	29.3	0	SC	C[1]	5×10^4	---	Mafic lava	88	600
14S/12E-13DC	DESC8593	City of Redmond MW-8	11.4	24	8.25	0	S	C[2]	1.8×10^2	---	Basalt	13	14
15S/10E-05BBB	DESC2999	Tollgate	1,210	48	4.5	0	SC	C[3]	1×10^4	---	Glacial outwash & mafic lava	100	100
15S/13E-20CDC	DESC0407	City of Redmond Well 4	*2,751	72	1.8	844	T	C[4]	6×10^3	.1	Sand & gravel	100	60
15S/13E-22CBA2	DESC3951	City of Redmond Well 3	1,141	72	.16	350	T, SL	S	2.0×10^5 to 3.0×10^5	.05	Sand & gravel, lava	132	1.5×10^3 to 2.3×10^3
17S/11E-11BAs	DESC1304	Awbrey Butte	225	24	.65	0	SC	C[5]	1×10^5	---	Basalt with minor cinders	105	100
18S/9E-02BDA	DESC5215	Mount Bachelor	110	18	39	0	SC	C[6]	5×10^2	---	Basaltic cinders	56	9
18S/12E-05CAB	DESC5579	Brooks-Scanlon No. 1	1,270	17	7.61	0	SC	C[7]	5×10^4	---	Lava & tuff	253	1.5×10^2
18S/12E-07DBD2	DESC9108	City of Bend Rock Bluff	722	24	.06	210	---	S	---	---	Basaltic cinders	395	---
18S/12E-16BCC3	DESC5613	Juniper Utility	1,300	3	1.14	35	---	S	---	---	Lava & cinders	122	---

Sources for tests by private consultants:

[1] Century West Engineering Corporation, 1990, Regional hydrogeologic investigation for the proposed Shadow Mountain R.V. Park, Sisters, Oregon.

[2] Cascade Earth Sciences Limited, 1994, City of Redmond, Oregon, wastewater treatment system expansion: hydrogeologic characterization report.

[3] Century West Engineering Corporation, 1990, Preliminary pump test data and groundwater material for the proposed Shadow Mountain R.V. Park, Sisters, Oregon.

[4] Century West Engineering Corporation, 1985, Assessment of water availability, Redmond, Oregon.

[5] W and H Pacific, 1994, Brooks Resources Corporation groundwater appropriation claim of beneficial use and site report, Permit No. G-1106.

[6] Century West Engineering Corporation, 1984, Water-supply study for Mount Bachelor.

[7] CH2M, 1964, A report on an engineering study of the municipal water system, city of Bend, Oregon.

Transmissivity estimates from aquifer tests are affected by well construction and the thickness of the aquifer open to the well. In order to allow meaningful comparisons between aquifer tests, transmissivity estimates can be normalized by dividing them by the length of the open interval below the water table in the pumped well to derive an estimated hydraulic conductivity. Hydraulic-conductivity values so calculated are included in table 1. Hydraulic-conductivity estimates derived from aquifer tests vary more than two orders of magnitude, from less than 10 to nearly 1,900 ft/d. The variation in hydraulic conductivity of subsurface materials is undoubtedly much greater than indicated by the tests. Production zones in wells are not a true sample of the range in hydraulic conductivities in the subsurface because the wells are selectively open to the most permeable strata and less permeable zones are not represented.

Hydraulic-conductivity values from the available tests do not correlate well with rock type. Tests yield a wide range of values from both volcanic and sedimentary aquifers. This is not surprising because hydraulic conductivities of both types of materials can range over several orders of magnitude (Freeze and Cherry, 1979, table 2.2). The small number of tests precludes determination of the spatial distribution of hydraulic conductivity. The highest hydraulic-conductivity values, however, are associated with Deschutes Formation materials, including basaltic lava and vent deposits, and sand and gravel deposits likely belonging to the ancestral Deschutes River channel facies described by Smith (1986).

Well-Yield Tests

Another source of information on subsurface hydraulic characteristics are the well-yield tests conducted by drillers and reported on the well logs submitted on completion of all new wells. Well-yield tests generally consist of a single drawdown measurement taken after a well has been pumped at a specified rate for a specified length of time, typically 1 hour. Well-yield tests allow determination of a well's specific capacity, which can be used to estimate transmissivity as described previously. Specific capacity is only a semiquantitative measure of well performance in that it can vary with pumping rate. Specific-capacity values can be used to calculate only rough estimates of the aquifer transmissivity and provide no information on the aquifer storage characteristics. Although transmissivity values calculated from specific-capacity tests are only approximate, they can be used to evaluate the relative differences in hydraulic characteristics between different geographic areas if data are available from a sufficient number of wells.

Well-yield tests were evaluated from 1,501 field-located water wells (raw data are in Caldwell and Truini, 1997). Of these tests, 390 were air-lift tests, in which the water is blown out of the well using compressed air, precluding measurement of drawdown and calculation of specific capacity. An additional 152 tests had information that was incomplete in some other way. Of the 959 remaining yield tests, 453 had pumping (or bailing) rates that did not sufficiently stress the aquifer to produce a measurable effect in the well, and zero drawdown is indicated on the well log.

This precludes calculation of a specific capacity because if drawdown is zero then specific capacity is infinite, a physical impossibility. Eliminating wells with drawdown shown as zero from the data set would have selectively removed wells representing the most transmissive areas. To avoid biasing the data in this manner, wells with zero drawdown were arbitrarily assigned a drawdown of 1 ft, which is the limit of precision to which most drillers report water levels, and probably the limit to which it is measured during bailer tests. Statistics for specific capacities derived from well-yield tests in the study area and from various subareas within the study area are shown in table 2.

A map showing the geographic distribution of transmissivity estimates derived from well-yield tests can be used to help understand spatial variations in aquifer

Table 2. Statistics for transmissivities (square feet per day) estimated from specific-capacity data for subareas in the upper Deschutes Basin, Oregon.

[*, includes wells outside the listed subareas]

Area	Minimum	25th Percentile	Median	75th Percentile	Maximum	Number of wells
La Pine Subbasin Alluvium	7.1	342	901	1,953	114,297	175
Deschutes Formation West	11.4	617	1,917	3,587	1,458,724	382
Deschutes Formation East	12.6	1,099	2,337	4,063	221,887	209
Inactive Margin	1.1	46.2	796	2,225	59,683	92
All located wells*	1.1	518	1,821	3,660	1,458,724	959

characteristics. When creating such maps, it is important to include only wells with comparable construction. Certain wells, such as high-yield municipal and irrigation wells are constructed to be very efficient, and consequently have higher specific capacities than small-yield household wells in the same aquifer. Therefore, it is desirable to use only wells with comparable construction when creating maps showing transmissivities estimated from specific-capacity data.

The geographic distribution of transmissivities estimated from specific capacities of 623 household wells is shown in figure 5. Although a wide range of transmissivity values occurs throughout the areas represented, some subtle patterns are apparent. The La Pine subbasin, the area just north of Bend, Jefferson County, and the eastern margin of the study area show the highest incidence of wells with low transmissivity values. The areas east of Bend, between the Crooked and Deschutes Rivers near Redmond, and west of Sisters show the highest incidence of high transmissivity wells. This distribution is consistent with the results of aquifer tests and with the regional geology. The areas where transmissivities appear to be slightly higher coincide with regions of coarse-grained sedimentary deposits, such as the glacial outwash west of Sisters and the ancestral Deschutes River channel deposits in the Redmond area. The areas where transmissivities appear lower coincide, at least in part, with regions where fine-grained materials predominate, such as the La Pine subbasin, or regions where older rock or sediments derived from older rock predominate, such as the eastern and northern parts of the upper Deschutes Basin.

The aquifer tests described above provide information on aquifer characteristics at specific locations, and taken as a group provide a general picture of the minimum range of conditions and of geographic variations in the areas represented. The specific-capacity values from well-yield tests provide a rough picture of the geographic distribution of transmissivity. The aquifer-test and specific-capacity data described in this section, however, represent only a small part of the flow system. There are large geographic areas in the upper basin, such as the Cascade Range and Newberry Volcano area, where there are virtually no data. Moreover, in areas of the upper Deschutes Basin where wells are plentiful, most wells penetrate only the upper part of the saturated zone and may not be representative of the deep parts of the flow system.

Ground-Water Recharge

The Deschutes Basin ground-water flow system is recharged by infiltration of precipitation (rainfall and snowmelt), leakage from canals, infiltration of applied irrigation water that percolates below the root zone (on-farm losses), and leakage from streams. Recharge from all of these processes is discussed in this section. The amounts of recharge from each of the processes cannot be simply summed to determine the net recharge for the upper Deschutes Basin because some water cycles into and out of the ground-water system twice. For example, the water that recharges the ground-water system through canal leakage originates as streamflow, a large percentage of which originates as springflow in the Cascade Range. The ground water supplying the springs originates from infiltration of precipitation in the Cascade Range.

Infiltration of Precipitation

Recharge from precipitation occurs where rainfall or snowmelt infiltrates and percolates through the soil zone and, eventually, reaches the saturated part of the ground-water flow system. Recharge is the quantity of water remaining after runoff and evapotranspiration take place.

The spatial and temporal distribution of ground-water recharge to the upper Deschutes Basin from infiltration of precipitation were estimated for water years 1962–97 using a water-balance model. The model, referred to as the Deep Percolation Model, or DPM, was developed by Bauer and Vaccaro (1987) for a regional analysis of the Columbia Plateau aquifer system in eastern Washington. The DPM is based on well-established empirical relations that quantify processes such as interception and evaporation, snow accumulation and melt, plant transpiration, and runoff. The DPM has been successfully applied to estimate regional recharge for studies of the Goose Lake Basin in Oregon and California (Morgan, 1988), the Portland Basin in Oregon and Washington (Snyder and others, 1994), and several other areas in Oregon and Washington. A detailed description of the application of the DPM to the Deschutes Basin, including the data input, can be found in Boyd (1996). The following sections provide a summary of the methodology and results.

The DPM was applied to the entire upper Deschutes Basin by subdividing the basin into 3,471 equal-sized grid cells with dimensions of 6,000 ft by 6,000 ft (fig. 6). The DPM computed a daily water balance at each cell using input data describing the location, elevation, slope, aspect, mean annual precipitation, land cover, and soil characteristics of each cell. Daily data (precipitation, maximum and minimum temperature, solar radiation) from six weather stations (table 3) in the basin were used to compute daily moisture input and potential evapotranspiration at each cell. The six climate stations used were selected because they had the longest periods of record with the fewest occurrences of missing data among stations in the basin. Climate data were obtained from the Oregon Climate Service (1999).

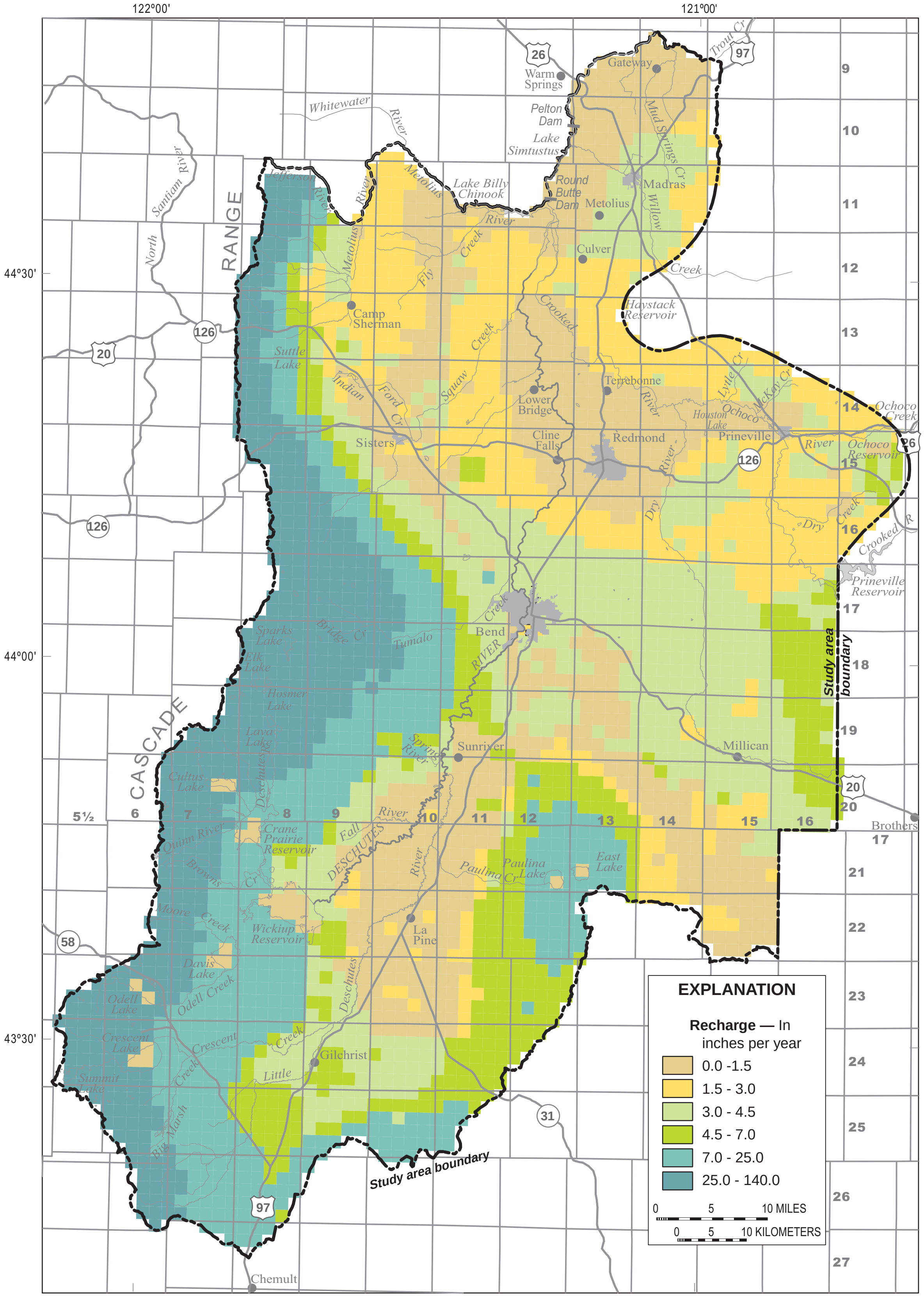

Figure 6. Deep Percolation Model grid and estimated recharge from infiltration of precipitation, 1993–95.

Table 3. Weather stations used for estimation of recharge from infiltration of precipitation with the Deep Percolation Model.

[ID, Identification; X, data collection]

Station name	Station ID	Elevation, in feet	Precipitation data	Temperature data	Solar radiation data
Bend	0694	3,650	X	X	
Brothers	1067	4,640		X	
Madras	5139	2,230	X		
Prineville	6883	2,840	X	X	
Redmond	7062	3,060	X	X	X
Wickiup Dam	9316	4,360	X	X	

The DPM requires that several types of data be specified for each cell: long-term average annual precipitation, land-surface elevation, slope, aspect, land-cover type, and soil type. Long-term average annual precipitation at each cell was derived from a statewide distribution for the 1961–90 period estimated by the Oregon Climate Service using the PRISM model (Daly and Nielson, 1992). PRISM uses digital topographic data to account for orographic effects on precipitation. The DPM uses the ratio of the long-term annual average precipitation at the cell to the long-term average at each climate station to interpolate daily precipitation values at each cell.

The mean elevation, slope, and aspect of each cell were calculated from 90-meter digital elevation data using a geographic information system (GIS). Elevation was used with temperature lapse rates to interpolate daily temperature values at each cell from the nearest climate stations. Slope at each cell was used to compute runoff and aspect was used to estimate incident solar radiation in the calculation of potential evapotranspiration.

Land-cover data from the Oregon Gap Analysis Program (J. Kagan, Oregon Natural Heritage Program, written commun., 1992) was used to specify four land-cover types in the model: forest, sage and juniper, grass, and surface water. These types covered 61, 36, 2, and 1 percent of the basin, respectively. Recharge from irrigated croplands was not estimated using DPM; estimates of recharge to these areas from canal leakage and on-farm losses are described later in this section. For each land-cover type, the maximum plant rooting depth, foliar cover fraction, and interception storage capacity were specified based on literature values (Boyd, 1996).

A statewide soil database (STATSGO) (U.S. Department of Agriculture, 1991) was used to specify soil type and associated parameters at each cell. A cluster analysis was used to aggregate the 26 general soil types found within the basin into 10 hydrologic soil types (Boyd, 1996). For each hydrologic soil type, thickness, texture, field capacity, specific yield, horizontal hydraulic conductivity, and vertical hydraulic conductivity were specified.

The DPM was used to compute daily water balances at each cell from January 1961 through November 1997. The daily recharge values were used to compute mean monthly and annual recharge values.

The distribution of mean annual recharge for water years 1993–95 (fig. 6) illustrates the strong relation between precipitation (fig. 3) and recharge. Recharge for the 1993–95 period was calculated to correspond to the calibration period for a steady-state numerical ground-water flow model. Computed recharge from precipitation ranged from less than 1 in/yr in the lower elevations, where annual precipitation is less than 12 inches, to more than 130 inches in the high Cascade Range, where soils are thin and precipitation locally exceeds 200 inches. The mean recharge for the basin during the 1993–95 water years was 10.6 in/yr; converted to a mean annual value for the 4,500 mi2 basin, this is the equivalent of about 3,500 ft^3/s (cubic feet per second).

Between 1962 and 1997, estimated recharge ranged from less than 3 inches in the drought years of 1977 and 1994 to nearly 23 inches in 1982 (fig. 7). The mean for the 26-year period was 11.4 in/yr, which converts to an annual rate of about 3,800 ft^3/s. The estimated evapotranspiration for the basin is relatively constant from year to year because the effects of above or below normal precipitation are dampened by storage in the soil moisture zone. Runoff is a relatively small component of the total water budget in the Deschutes Basin due to high infiltration rates of the permeable volcanic soils. The Deschutes and Metolius Rivers are noted for their extraordinarily constant flows that are sustained primarily by ground-water inflow. Recharge averages about 35–40 percent of annual precipitation within the basin, but ranges from less than 5 percent at low elevations, where potential evapotranspiration greatly exceeds precipitation, to as much as 70 percent at higher elevations, where annual precipitation may be several times greater than potential evapotranspiration.

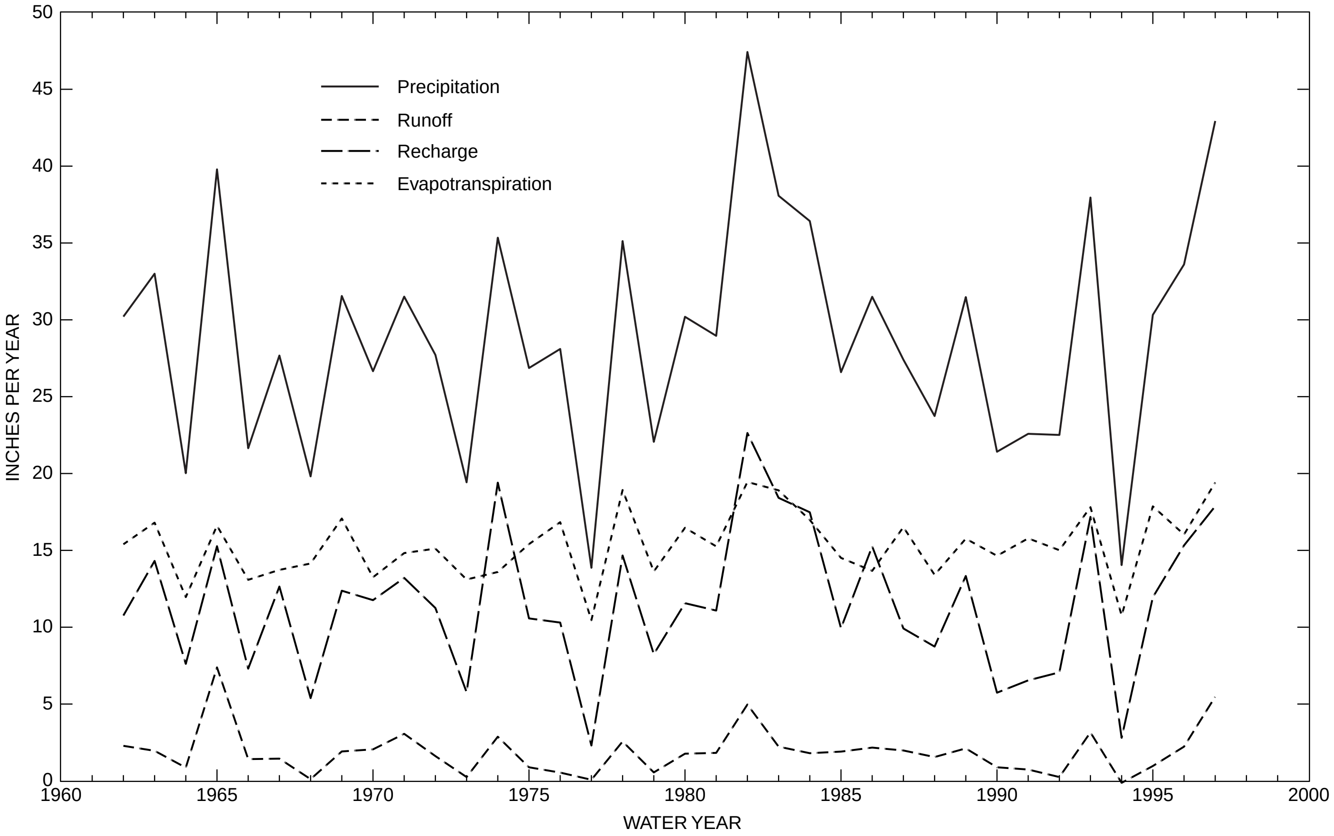

Figure 7. Annual mean components of the basinwide water budget, estimated using the Deep Percolation Model for water years 1962–97.

Manga (1997) developed a physically based model using the Boussinesq equation (Boussinesq, 1904) to estimate recharge rates within the contributing areas of four spring-dominated streams tributary to the Deschutes River above Benham Falls. Results agreed well with those from the DPM for the area. Within the inferred contributing areas to all four streams, mean DPM recharge was 29 in/yr (1962–97) and mean recharge estimated by Manga was 28 in/yr (1939–91). Manga's estimated recharge averages 56 percent of precipitation within the contributing area of the four streams, while the DPM recharge was approximately 45 percent of precipitation within the same area.

About 84 percent of recharge from infiltration of precipitation occurs in the Deschutes Basin between November and April (fig. 8). According to the DPM, recharge rates peak in December and again in March–April. The December recharge peak results from deep percolation of precipitation after heavy fall rains and early winter snowfall and melt have saturated soils. After January, precipitation is reduced, but snowmelt sustains recharge at higher elevations through April. By May, increasing evapotranspiration begins to deplete soil moisture storage and reduce recharge rates to nearly zero.

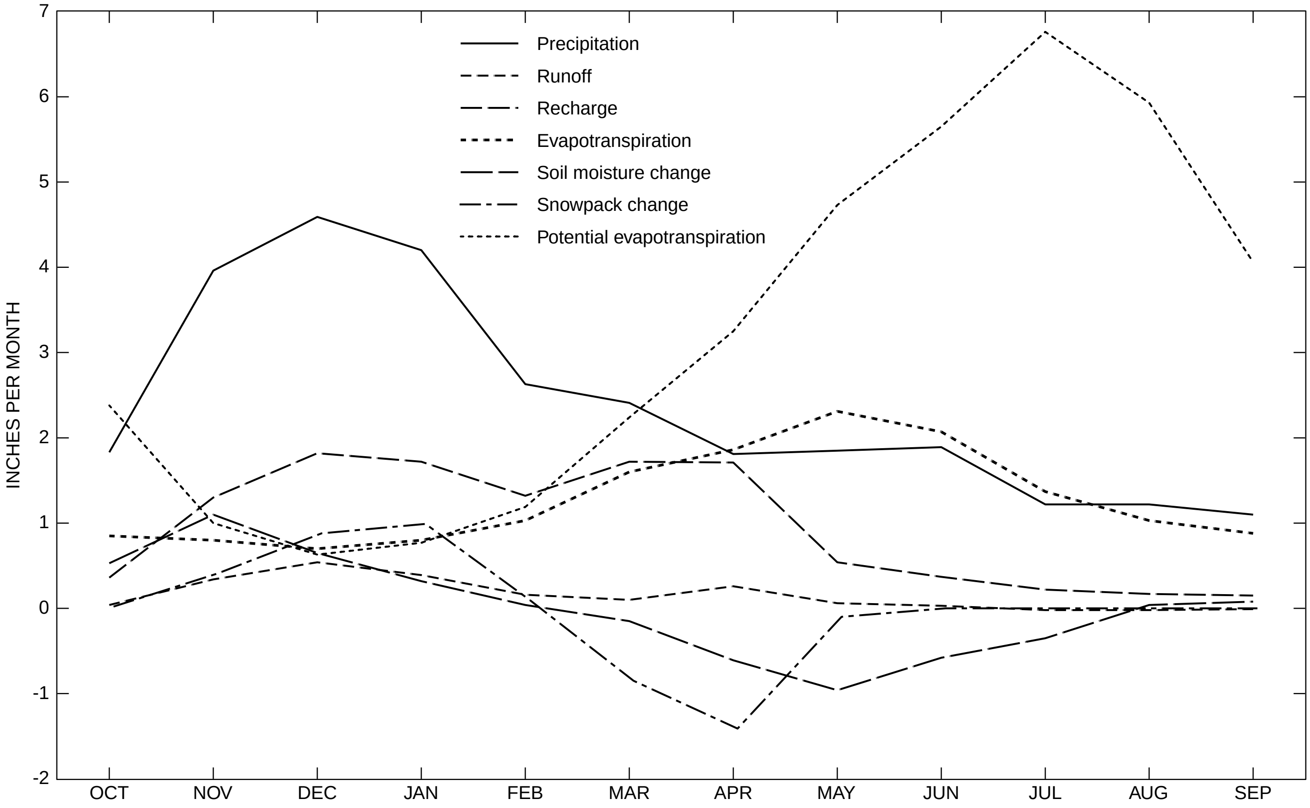

Figure 8. Mean monthly components of the basinwide water budget, estimated using the Deep Percolation Model for water years 1962–97.

Canal Leakage

There are approximately 720 miles of canals and laterals that carry water diverted from the Deschutes and Crooked Rivers to more than 160,000 acres of irrigated lands in the basin. Many of the canals are cut into young basaltic lava that is blocky and highly fractured; these canals lose large quantities of water. Most of the leakage percolates to the water table and is a significant source of ground-water recharge in the irrigated parts of the basin (fig. 9).

Canal leakage was estimated for the 1994 irrigation season (May–September) using several sources of information, including: (1) diversions into canals measured at gaging stations operated by the OWRD, (2) estimates of irrigated acreage and crop-water applications from satellite imagery, (3) estimates of canal leakage rates from ponding experiments and surveys of canal-bottom geology by BOR (Bureau of Reclamation, 1991a, 1991b), and (4) estimates of irrigation efficiency by BOR (Bureau of Reclamation, 1993).

The 1994 canal leakage volume was calculated as the residual of the volume of water diverted into canals minus the volume of water delivered to farms. The areal distribution of canal leakage in the main canals and laterals was estimated on the basis of information on canal-bottom geology and ponding experiments.

To determine the on-farm deliveries from each canal in 1994, it was necessary to estimate the irrigated acres within each canal service area, the amount of water actually needed for the crops to grow (crop-water requirement), and the average irrigation efficiency within the canal service area. The actual crop-water application is equal to the crop-water requirement divided by the irrigation efficiency. For example, if the crop-water requirement were 2.0 ft/yr (feet per year) and the irrigation efficiency were 0.50, the crop-water application would be 4.0 ft/yr.

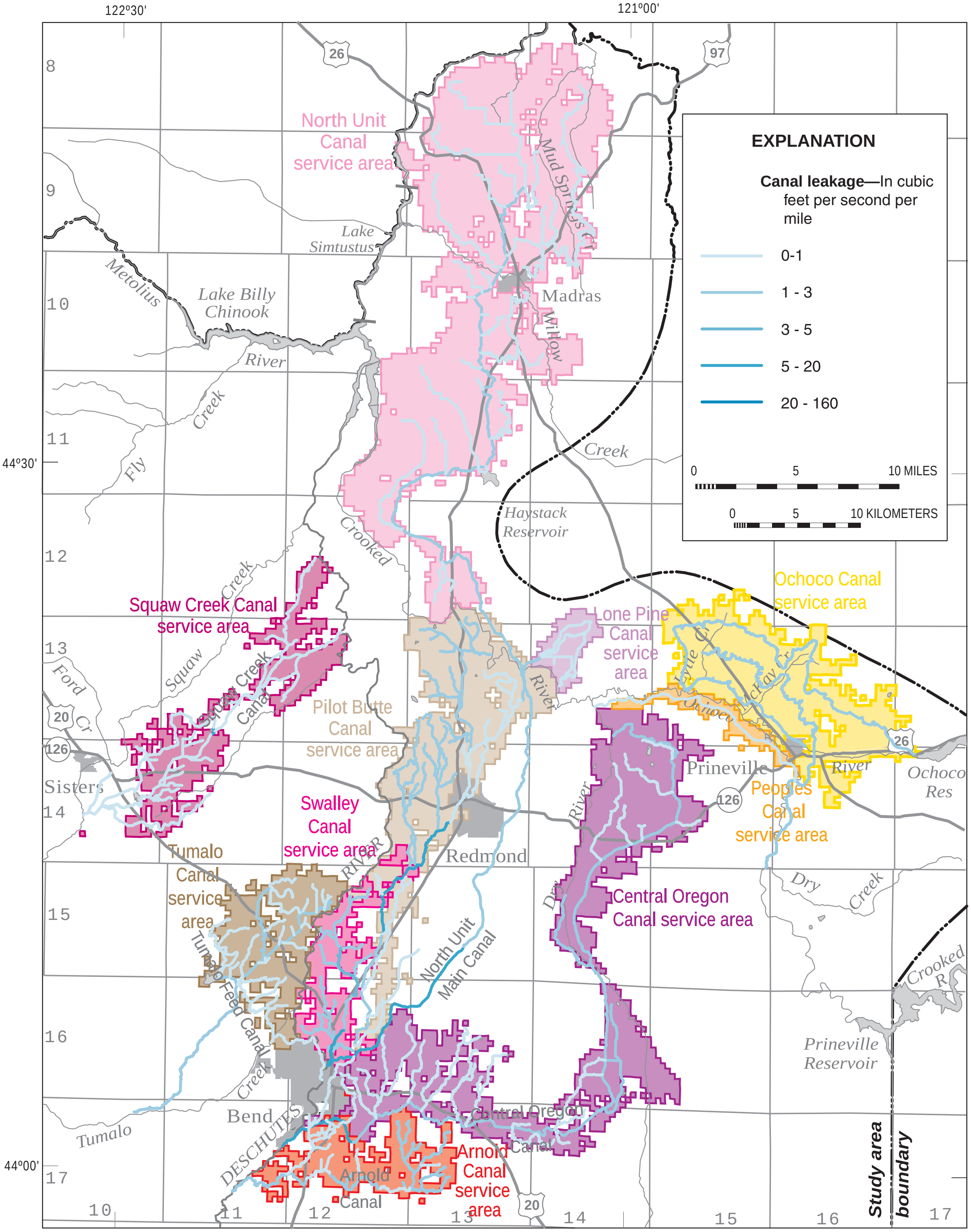

Figure 9. Mean annual recharge from canal leakage and on-farm losses in the upper Deschutes Basin, Oregon, 1993–95.

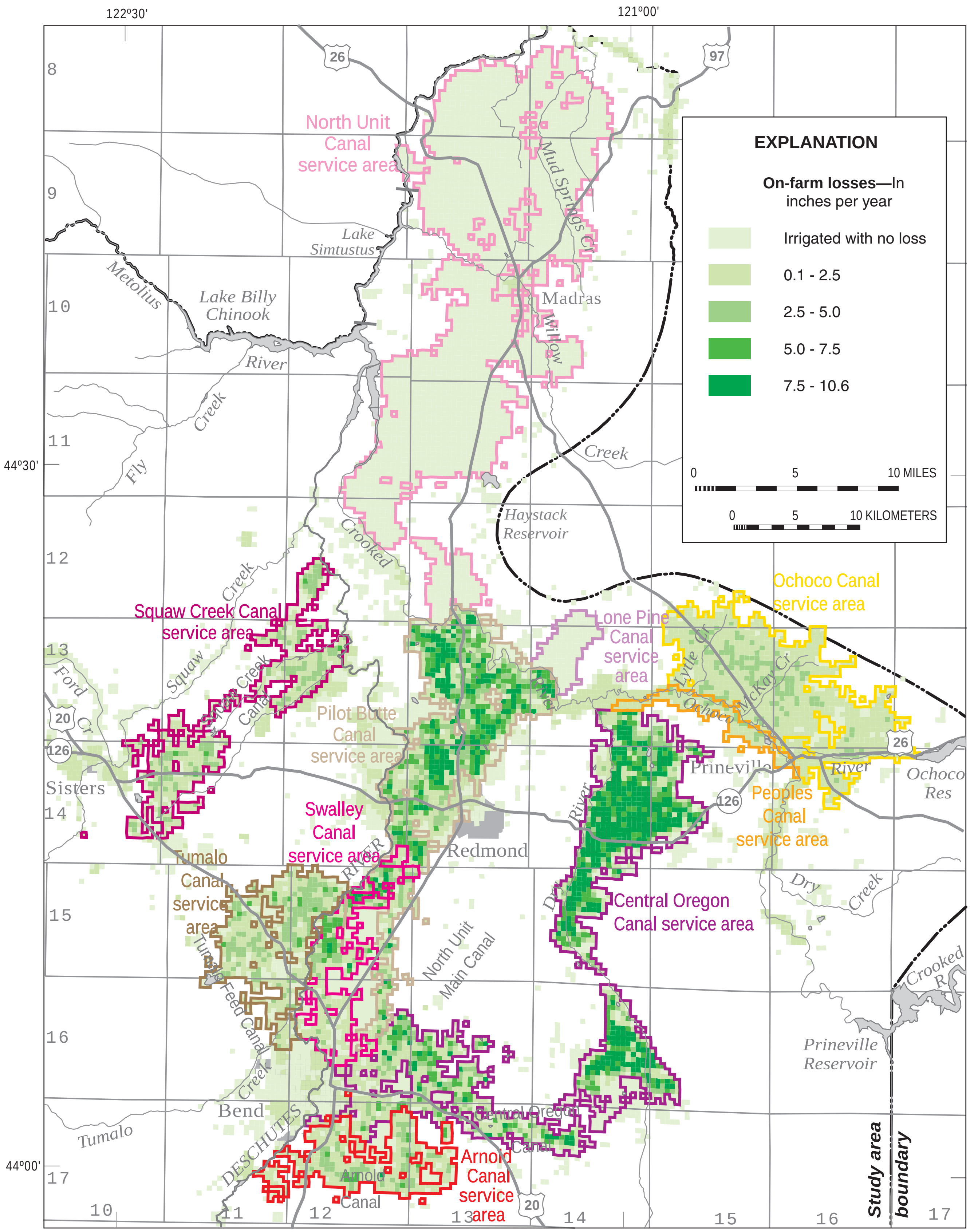

Figure 9.—Continued.

Satellite imagery was used to map 164,000 acres of irrigated croplands in the basin in 1994 and classify them according to the relative magnitude of crop-water requirements. The three classifications used were low, medium, and high water requirement crops. Of the total irrigated acreage, low water requirement crops made up 33,000 acres, medium water requirement crops made up 24,000 acres, and high water requirement crops made up 107,000 acres. Water-rights information from the OWRD was used to determine that ground water was the source of irrigation to approximately 13,000 acres, with surface water supplying the remaining 151,000 acres.

The water requirement for each crop classification was estimated based on tables for the region (Cuenca and others, 1992; Bureau of Reclamation, 1995). County crop census data (Oregon State University, Extension Service, written commun., 1996) was used to weight the crop-water requirements to reflect the variability of crops grown in different parts of the basin. Climatic variability was accounted for by dividing the study area into northern and southern regions and applying appropriate crop-water requirements to irrigated lands in each region. The boundary between the regions coincides with the Deschutes–Jefferson County line (fig. 1). The low water requirement crop classification contained mostly fallow land; therefore, the water requirement was assumed to be zero for these areas. In 1994, medium water requirement crops were assumed to need 1.5 acre-feet per acre in the northern region and 1.7 ft in the southern region, while high water requirement crops were assumed to need 2.7 ft in the northern region and 2.4 ft in the southern region.

Irrigation efficiency depends primarily on the method used to apply the irrigation water. Sprinkler irrigation is the most efficient method and typically results in efficiencies of 75 to 90 percent. Flood irrigation is the least efficient and efficiencies of 35 to 50 percent are typical (U.S. Department of Agriculture, 1993). Irrigation efficiencies for each canal service area were estimated based on BOR studies in the basin (Bureau of Reclamation, 1993) and from interviews of local irrigation district and extension service personnel.

The total irrigation-water deliveries to farms within each canal service area, I_c, in acre-feet per year, were calculated:

$$I_c = (A_h \quad C_h / E_c) + (A_m \quad C_m / E_c), \tag{1}$$

where

A_h and A_m are the areas of high and medium water-use crops, in acres,

C_h and C_m are the crop-water requirements for high and medium water-use crops, in feet per year, and

E_c is the average irrigation efficiency for the canal service area, in decimal percent.

Total 1994 diversions, irrigated acreage, on-farm deliveries, and canal leakage are listed for each major canal in table 4.

Canal leakage rates vary greatly within the study area depending on the geology of the canal bottom, the degree to which cracks and voids have been filled by sediment, and the wetted perimeter of the canal. The estimated total leakage within each canal service area (table 4) was apportioned among the canal and laterals on the basis of information available from studies by the BOR (Bureau of Reclamation, 1991a, 1991b, 1993). The BOR conducted ponding experiments in several canal reaches and determined leakage rates ranging from 0.64 to 4.20 $ft^3/d/ft^2$. This information was extrapolated using geologic mapping of the canal bottoms to estimate leakage rates for most of the main canals and laterals in the study area (fig. 9). The wetted area of each canal reach was calculated from the average width, depth, and length of the canal. Leakage rates were multiplied by wetted area to obtain estimates of leakage from each canal reach within a canal service area. If the total leakage did not match the total estimated as the residual of diversions minus on-farm deliveries, then the leakage rates were adjusted until the totals matched.

In 1994, 356,600 acre-ft, or 490 ft^3/s, leaked through canal bottoms to become ground-water recharge (table 4). This amounted to 46 percent of the 770,400 acre-ft (1,060 ft^3/s) diverted into canals in the upper Deschutes Basin. Canal leakage for the period 1905–97 was estimated for the basin assuming that the same proportion (46 percent) of diversions would be lost each year (fig. 10). Canal leakage peaked in the late 1950s when mean annual diversions were approximately 940,000 acre-ft (1,300 ft^3/s) and nearly 435,000 acre-ft (600 ft^3/s) was lost to ground-water recharge.

Figure 9 shows the distribution of canal leakage in the basin for 1993–95. The highest rates of leakage occur in reaches of the North Unit and Pilot Butte canals immediately east and north of Bend. In these reaches, canals are cut through highly fractured, blocky basalt and were estimated to lose an average of more than 20 $ft^3/s/mi$ (cubic feet per second per mile) during 1993–95.

On-Farm Losses

Applied irrigation water can be lost to evaporation (from droplets, wetted canopy, soil and water surfaces), wind drift, runoff, and deep percolation. All of these losses are considered on-farm losses; however, the contribution of deep-percolation losses to ground-water recharge was the part of the loss of direct interest to this study. On-farm losses are directly correlated with irrigation efficiency. Irrigation efficiency is the ratio of the depth of irrigation water used by the plant to the depth of irrigation water applied, expressed as a percentage.

Table 4. Canal diversions, irrigated acreage, on-farm deliveries, and canal leakage, by major canal service area, uper Deschutes Basin, Oregon, 1994.

[All values in acre-feet unless otherwise noted; ft/yr, feet per year; ---, not applicable]

Canal	A Canal diversions	B Irrigated area [1] (acres)	C Mean crop water requirement (ft/yr)	D Crop water needs (B × C)	E Mean irrigation efficiency (percent)	F Estimated deliveries (D / E)	G Canal losses (A–F)
Arnold	26,570	2,310	2.25	5,200	0.50	10,400	16,170
Central Oregon	181,500	22,500	2.37	53,330	.43	124,020	57,480
North Unit	196,700	45,000	2.03	91,350	.94	97,180	99,520
Lone Pine	10,640	2,390	2.13	5,090	.89	5,720	4,920
Ochoco	75,000	16,600	2.12	35,190	.66	53,320	21,680
Peoples	6,500	1,540	2.21	3,400	.66	5,150	1,350
Pilot Butte	165,800	14,800	2.36	34,930	.43	81,230	84,570
Squaw Creek	26,400	5,450	1.50	8,180	.62	13,190	13,210
Tumalo	42,600	4,890	2.31	11,300	.60	18,830	23,770
Swalley	38,700	2,450	2.33	5,710	.51	11,200	27,500
Total	770,410	117,930	---	253,680	---	420,240	350,170
Average	---	---	2.15	---	.60	---	---

[1] Includes only high and meadium water-use crops.

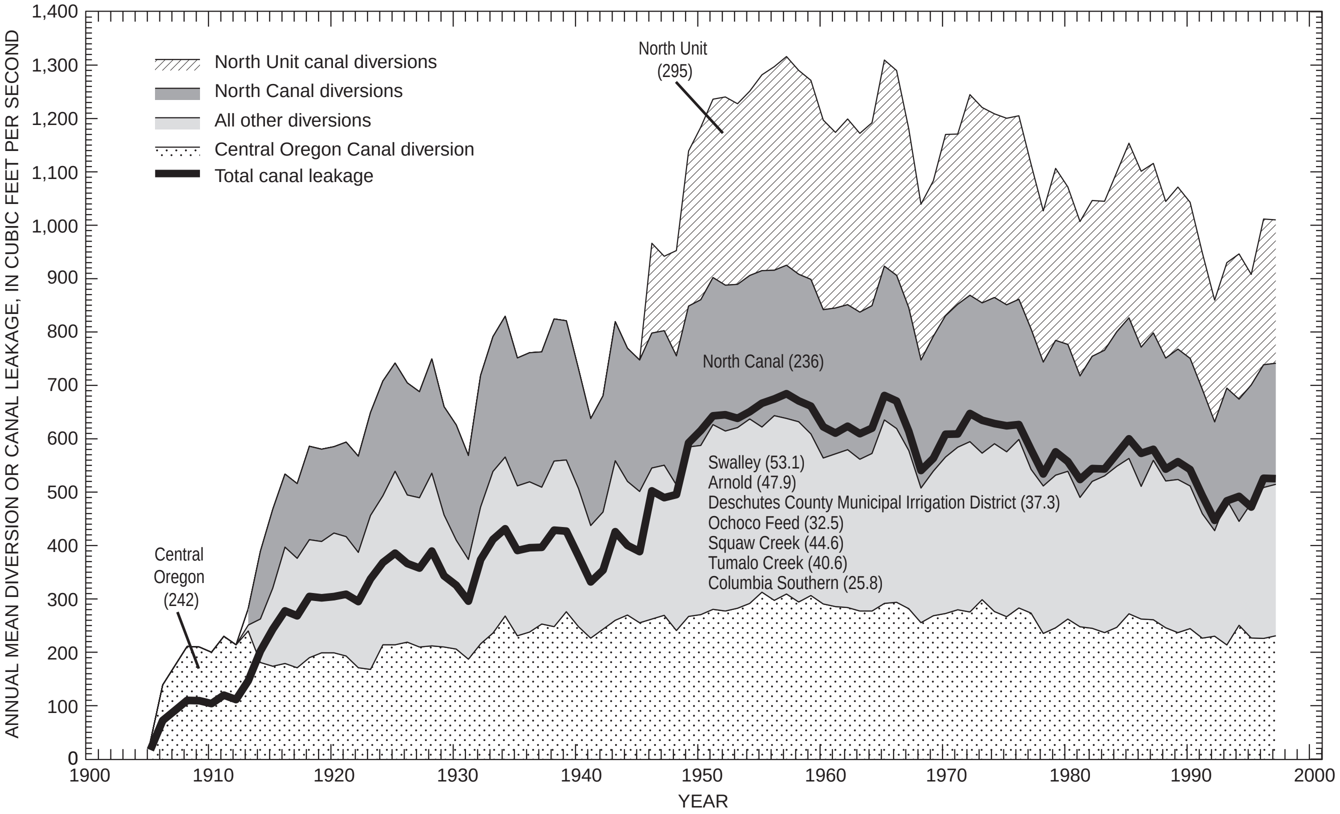

Figure 10. Annual canal diversions and estimated annual mean canal leakage in the upper Deschutes Basin, Oregon, 1905–97. (Mean annual discharge, in cubic feet per second, is shown in parentheses for the period of record for each diversion.)

As shown in table 4, estimated mean irrigation efficiencies in the study area vary from 43 percent in areas where flooding is the primary method of application to 94 percent where sprinklers are the primary method.

Literature values were used to estimate losses to evaporation, wind drift, and runoff. The percentage of applied irrigation water lost to these sources is highly variable and dependent on individual water-management practices and soil and climatic conditions. A maximum of 20 percent was assumed to be lost to these sources throughout the study area (U.S. Department of Agriculture, 1993). For example, where the irrigation efficiency is 60 percent (60 percent of the applied water is used by the plant), of the remaining 40 percent of applied water, 20 percent is assumed to be lost to evaporation, wind drift, and runoff, while 20 percent is assumed to be lost to deep percolation. In areas of sprinkler irrigation with efficiencies of 94 percent, only 6 percent of applied water is lost (mostly to evaporation and wind drift), and no water is assumed to be lost to deep percolation.

Mean annual recharge (1993–95) from deep percolation of on-farm losses was only about 49,000 acre-ft (68 ft^3/s) (fig. 9). The service area for the North Unit canal is almost entirely irrigated by sprinkler; therefore, no recharge from on-farm losses were estimated in this area. In other areas, where a mixture of flood and sprinkler irrigation is used, up to 5 in/yr of recharge occurs from on-farm losses. Areas where flood irrigation is the predominant irrigation method receive recharge of up to 10 in/yr from on-farm losses.

Stream Leakage

Where the elevation of a stream is above that of the water table in adjacent aquifers, water can leak from the stream to the underlying strata and recharge the ground-water system. Such streams are termed *losing streams*. Conversely, in areas where the stream elevation is below that of adjacent aquifers, ground water can discharge to streams, increasing streamflow. Such streams are termed *gaining streams*.

In this study, ground-water flow from and to streams was estimated using data from a variety of sources. The primary sources of information were sets of streamflow measurements known as *seepage runs*. A seepage run consists of a series of streamflow measurements taken a few to several miles apart along a stream over a short enough period that temporal variations in streamflow are minimal. Tributary inflow and diversions are measured as well. Any temporal changes in streamflow occurring during the measurement period also are measured or otherwise accounted for. Seepage runs provide a snapshot of the rate and distribution of ground-water inflow to, or leakage from, a stream; single seepage runs, however, do not provide information on temporal variations in stream gains and losses. Seepage runs were conducted along all major streams in the upper Deschutes Basin by OWRD, and multiple runs were conducted on certain streams. Data from the seepage runs were provided by Kyle Gorman, OWRD (written commun., 1994, 1995, 1996) and are presented in table 5.

The methods used to measure streamflow have an inherent error of plus or minus 5 percent under good measurement conditions. Therefore, streamflow variations of less than 5 percent measured between two points during a seepage run may represent measurement error and not an actual gain or loss. However, if the sum of such small gains or losses along a reach exceeds the likely measurement error, it is reasonable to assume there is an actual gain or loss.

Data from stream-gaging stations also were useful in estimating the amount of ground water discharging to or leaking from streams. Because stream gages operate continuously, they can provide information on temporal changes in gains and losses. Most stream-gage data used in this section and the following section on ground-water discharge were from the USGS National Water Information System (NWIS). Additional data were obtained from published compilations (U.S. Geological Survey, 1958; Oregon Water Resources Department, 1965). The locations of gaging stations used in this report are shown in figure 11, and the station numbers and names are listed in table 6. Some statistical summaries were taken from Moffatt and others (1990). Data from OWRD gages and irrigation diversions were provided by the OWRD (Kyle Gorman, written commun., 1998, 1999, 2000). Estimated stream gains and losses are presented in table 7 and shown graphically along with selected stream-gage locations in figure 12. Unless otherwise noted, the gain and loss rates in table 7 are assumed to represent average conditions.

In the upper Deschutes Basin, losing streams are much less common than gaining streams (fig. 12). The conditions required for losing streams, a water-table elevation below the stream elevation, occur much less commonly than the conditions required for gaining streams.

The rates of water loss from losing streams are usually much less than the rates of ground-water inflow to gaining reaches (fig. 12) because of differences in the ways water enters and leaves streams. In the upper Deschutes Basin, water typically enters streams from springs issuing from highly fractured lava or coarse sedimentary deposits like sands and gravels. These springs commonly occur above river level (Ferns and others, 1996), and there is no mechanism by which the fractures or other openings through which the water emerges can be effectively blocked. The fractures and openings through which water leaks from losing streams, in contrast, are much more easily blocked and sealed.

Table 5. Gain/loss measurements of major streams obtained from Oregon Water Resources Department seepage runs, upper Deschutes Basin, Oregon.

[Q, discharge in cubic feet per second at the measurement site; Trib Q, discharge in cubic feet per second of a tributary entering the stream of interest; Seepage, calculated seepage in cubic feet per second between the measurement site and the upstream measurement site (corrected for tributary inflow), negative value indicates a loss of water to the aquifer; USGS, U.S. Geological Survey; RM, river mile]

Site	River mile	Date	Q	Trib. Q	Seepage	Date	Q	Trib. Q	Seepage	Comments
Little Deschutes River										
Cow Camp	86.0	10/10/95	19.7	--	--	--	--	--	--	
Highway 58	80.0	10/10/95	31.5	--	11.8	--	--	--	--	
Forest Service Road	71.0	10/10/95	28.9	--	-2.6	--	--	--	--	
Above Gilchrist Pond	64.5	10/10/95	26.9	--	-2.0	10/9/96	32.4	--	--	
Above Crescent Creek	57.5	10/10/95	15.9	--	-11.0	10/9/96	18.0	--	-14.4	
Wagon Trail Ranch	43.0	10/10/95	50.4	32.2	2.3	--	--	--	--	Tributary: Crescent Creek
Road Crossing (off 6th St. West of La Pine)	33.5	10/10/95	53.3	--	2.9	--	--	--	--	
Little Deschutes near La Pine (USGS gaging station 14063000)	26.7	10/10/95	53.3	--	0.0	10/9/96	54.7	--	--	
State Recreation Road	13.7	10/10/95	55.9	--	2.6	10/9/96	57.7	--	3.0	
South Century Drive	5.5	10/10/95	59.2	--	3.3	10/9/96	59.9	--	2.2	
Above Mouth at Crosswater	1.4	10/10/95	57.4	--	-1.8	10/9/96	57.0	--	-2.9	
Crescent Creek										
Below Crescent Lake	30	10/10/95	5	--	--	--	--	--	--	
Highway 58 crossing	18.5	10/10/95	33.7	10	18.7	--	--	--	--	Tributary Q estimated
Above Mouth	2.2	10/10/95	32.2	--	-1.5	--	--	--	--	
Fall River										
Near headwaters	9.0	2/21/96	18.3	--	18.3	--	--	--	--	
Near La Pine (USGS gaging station 14057500)	5.0	2/21/96	119	--	100.7	--	--	--	--	
Near mouth	0.4	2/21/96	112	--	-7.0	--	--	--	--	
Upper Deschutes River										
Below Wickiup Dam (USGS gaging station 14056500)	226.7	2/21/96	128	--	--	--	--	--	--	
Pringle Falls	217.6	2/21/96	126	--	-2.0	--	--	--	--	
La Pine State Park	208.6	2/21/96	132	--	6.0	--	--	--	--	
General Patch Bridge	199.7	2/21/96	268	112	24.0	--	--	--	--	
Harper’s Bridge	191.7	2/21/96	758	544	-54.0	--	--	--	--	Tributary Q measured at RM 26.8
Benham Falls (USGS gaging station 14064500)	181.4	2/21/96	1,047	--	289.0	--	--	--	--	Includes inflow from Spring River
Indian Ford Creek										
Black Butte Ranch Weir	10.7	2/5/92	5.86	--	5.86	4/23/92	6.42	--	6.42	
Willows Ranch Diversion	8.0	2/5/92	4.31	--	-1.55	4/23/92	4.62	--	-1.8	
Willows Ranch	3.6	2/5/92	4.43	--	0.1	4/23/92	3.15	--	-1.5	
Camp Polk Road	2.1	2/5/92	3.02	--	-1.4	4/23/92	2.94	--	-0.2	
Sisters Airport	1.3	2/5/92	0.01	--	-3.0	4/23/92	0.47	--	-2.5	
Barclay Road	0.8	2/5/92	0.00	--	0.0	4/23/92	0.00	--	-0.5	
Confluence with Squaw Creek	0.0	2/5/92	0.00	--	0.0	4/23/92	0.00	--	0.0	

Table 5. Gain/loss measurements of major streams obtained from Oregon Water Resources Department seepage runs, upper Deschutes Basin, Oregon.—Continued

[Q, discharge in cubic feet per second at the measurement site; Trib Q, discharge in cubic feet per second of a tributary entering the stream of interest; Seepage, calculated seepage in cubic feet per second between the measurement site and the upstream measurement site (corrected for tributary inflow), negative value indicates a loss of water to the aquifer; USGS, U.S. Geological Survey; RM, river mile]

Site	River mile	Date	Q	Trib. Q	Seepage	Date	Q	Trib. Q	Seepage	Comments
Lower Squaw Creek										
Brooks-Scanlon Logging Road	22	4/13/94	0.00	--	--	--	--	--	--	
Near Highway 20 Crossing	19	4/13/94	0.00	--	--	--	--	--	--	
Camp Polk Road Crossing	16.5	4/13/94	6.61	--	6.6	--	--	--	--	
Near Henkle Butte	14.7	4/13/94	7.30	--	0.7	--	--	--	--	
Below Squaw Creek Estates	9.9	4/13/94	6.46	--	-0.8	--	--	--	--	
Forest Road 6360 Crossing	5.5	4/13/94	6.61	--	0.2	--	--	--	--	
Above Alder Springs	1.7	4/13/94	7.46	--	0.9	--	--	--	--	
Below Alder Springs	1.05	4/13/94	26.50	--	19.0	--	--	--	--	
Middle Deschutes River										
Deschutes below Bend (USGS gaging station 14070500)	164.3	5/11/92	29.8	--	--	5/16/94	29.0	--	--	
Below mouth of Tumalo Creek	160.2	5/11/92	37.1	7.3	0.0	5/16/94	31.2	2.2	0.0	Tributary Q determined from gain
Tumalo State Park	158.8	5/11/92	39.7	--	2.6	5/16/94	42.3	--	11.1	
Deschutes River Ranch	154.5	5/11/92	43.8	--	4.1	5/16/94	43.7	--	1.4	
Above Eagle Crest	146.8	5/11/92	--	--	--	5/16/94	34.8	--	-8.9	
Cline Falls State Park	145.3	5/11/92	56.0	--	12.2	5/16/94	45.1	--	10.3	
Crestridge Estates	143.2	5/11/92	--	--	--	5/16/94	35.2	--	-9.9	
Tethero Road crossing	141.2	5/11/92	32.4	--	-23.6	5/16/94	36.8	--	1.6	
Odin Falls Ranch	138.0	5/11/92	--	--	--	5/16/94	35.5	--	-1.3	
Below Odin Falls Ranch	137.5	5/11/92	--	--	--	5/16/94	44.4	--	8.9	
Lower Bridge Road crossing	134.0	5/11/92	52.2	--	19.8	5/16/94	46.0	--	1.6	
NW Riffle Road	130.5	5/11/92	67.7	--	15.5	5/16/94	61.4	--	15.4	
Below fishing point near mine cabin	128.7	5/11/92	216	--	148.3	5/16/94	217	--	155.6	
Half mile below Steelhead Falls	127.2	5/11/92	223	--	7.0	5/16/94	--	--	--	
River Place below pump house	126.1	5/11/92	207	--	-16.0	5/16/94	--	--	--	
Sundown Canyon Road	124.9	5/11/92	226	--	19.0	5/16/94	213	--	-4	
Scout Camp Trail Road	123.3	5/11/92	365	--	139.0	5/16/94	341	--	128.0	
Below mouth of Squaw Creek	123.0	5/11/92	468	103	0.0	5/16/94	442	101	0.0	Tributary Q determined from gain
Deschutes River near Culver (USGS gaging station 14076500)	120.0	5/11/92	480	--	12.0	5/16/94	467	--	25.0	
Lower Crooked River										
Crooked River near Terrebonne	27.6	6/22/94	10.5	--	--	--	--	--	--	
Trail Crossing	20.4	6/22/94	23.6	--	13.1	--	--	--	--	
At Osborne Canyon	13.8	6/22/94	93.5	--	69.9	--	--	--	--	
Crooked River below Opal Springs (USGS gaging station 14087400)	6.7	6/22/94	1,100	--	1,006.5	--	--	--	--	

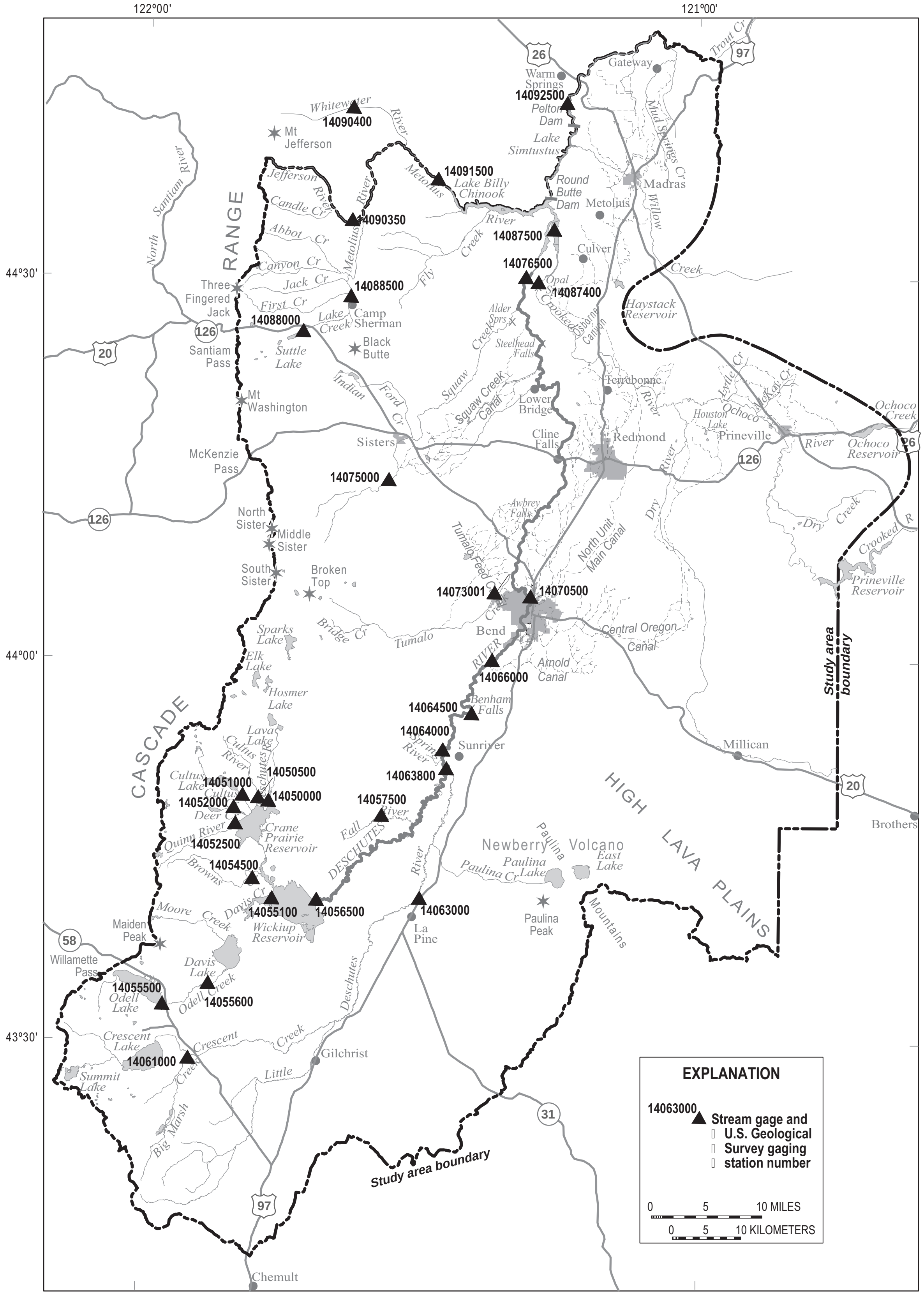

Figure 11. Location of selected stream-gaging stations in the upper Deschutes Basin, Oregon.

Table 6. Station numbers, names, and mean annual flow for selected gaging stations in the upper Deschutes Basin, Oregon.

[All data are from Moffatt and others (1990) unless noted; OWRD, Oregon Water Resources Department]

Station number	Station name	Mean annual flow	Period of record
14050000	Deschutes River below Snow Creek, near La Pine	151	1938 to 1987
14050500	Cultus River above Cultus Creek, near La Pine	63	1923 to 1987
14051000	Cultus Creek above Crane Prairie Reservoir, near La Pine	22	1924 to 1962
14052000	Deer Creek above Crane Prairie Reservoir, near La Pine	7.5	1924 to 1987
14052500	Quinn River near La Pine	24	1938 to 1987
14054500	Browns Creek near La Pine	38	1923 to 1987
14055100	Davis Creek (OWRD gage data)[1]	191	1939 to 1942
14055500	Odell Creek near Crescent	82	1913 to 1976
14055600	Odell Creek (OWRD gage data, gage several miles downstream of gage 14055500)[2]	126	1970 to 1990
14056500	Deschutes River below Wickiup Reservoir, near La Pine	754	1943 to 1987
14057500	Fall River near La Pine	150	1938 to 1987
14061000	Big Marsh Creek near Hoey Ranch, near Crescent	72	1912 to 1958
14063000	Little Deschutes River near La Pine	208	1924 to 1987
14063800	Deschutes River at Peters Ranch (OWRD gage data)[1]	1,210	1944 to 1953
14064000	Deschutes River at Camp Abbott Bridge (OWRD gage data)[1]	1,478	1944 to 1953
14064500	Deschutes River at Benham Falls, near Bend	1,480	1944 to 1987
14066000	Deschutes River below Lava Island, near Bend	1,380	1943 to 1965
14070500	Deschutes River below Bend	377	1957 to 1987
14073001	Tumalo Creek near Bend	101	1924 to 1987
14075000	Squaw Creek near Sisters	105	1906 to 1987
14076500	Deschutes River near Culver	929	1953 to 1987
14087400	Crooked River below Opal Springs, near Culver	1,610	1962 to 1987
14087500	Crooked River near Culver	1,560	1920 to 1960
14088000	Lake Creek near Sisters	52	1918 to 1987
14088500	Metolius River at Allingham Ranger Station, near Sisters[3]	376	1911 to 1912
14090350	Jefferson Creek near Camp Sherman[4]	94.9	1984 to 1999
14090400	Whitewater River near Camp Sherman[4]	86.6	1983 to 1999
14091500	Metolius River near Grandview	1,500	1912 to 1987
14092500	Deschutes River near Madras	4,750	1964 to 1987

[1] Oregon Water Resources Department (1965).

[2] Kyle Gorman, OWRD, written commun. (1999).

[3] U.S. Geological Survey (1958).

[4] Hubbard and others (2000).

Table 7. Estimated stream gains and losses due to ground-water exchange, upper Deschutes Basin, Oregon.

[RM, river mile; ft^3/s, cubic feet per second; OWRD, Oregon Water Resources Department; USGS, U.S. Geological Survey; Res., reservoir; NW, northwest; OSU, Oregon State University]

Stream Name	Reach (river mile)	Estimated gain (+) or loss (-) (ft^3/s)	Data source	Remarks
Little Deschutes River	Entire drainage above Highway 58, RM 80	31.5	OWRD measurements 10/95	Includes Hemlock Creek
Little Deschutes River	Highway 58 to above Crescent Creek, RM 80 to RM 57.5	-15.6	OWRD measurements 10/95	
Little Deschutes River	Above Crescent Creek to Crosswater, RM 57.5 to RM 1.4	9.3	OWRD measurements 10/95	
Big Marsh Creek	Drainage above gage near Mouth, RM 0.5	21	Statistical summary of gage 14061000 (Moffatt and others, 1990)	Mean September discharge, 1924–87
Crescent Creek	Crescent Lake outlet to Highway 58, RM 30 to RM 18.5	18.7	OWRD measurements 10/95	Includes inflow from Cold Springs Creek
Crescent Creek	Highway 58 to above mouth, RM 18.5 to RM 2.2	-1.5	OWRD measurements 10/95	
Paulina Creek	Paulina Lake outlet to Road 21, RM 13 to RM 5.2	-1.7 to -6.1	Morgan and others (1997)	
Odell Lake	Above gage at lake outlet	41	Statistical summary of gage 14055500 (Moffatt and others, 1990)	Mean September discharge, 1913–76
Odell Creek	Odell Lake outlet to OWRD gage	41	USGS and OWRD gage data for stations 14055500 and 14055600	Period of overlapping records from 1970 to 1976
Davis Creek	Upstream from RM 3	191	OWRD gage data for station 14055100 (1938–43), OWRD miscellaneous measurements 1978–94	Entire flow from springs
Cultus River	Above Cultus Creek	63	Statistical summary of gage 14050500 (Moffatt and others 1990)	Mean annual flow of spring-fed stream
Deschutes River	Above Crane Prairie Res.	151	Statistical summary of gage 14050000 (Moffatt and others, 1990)	Mean annual flow of spring-fed stream
Deschutes River	Crane Prairie Res. to Wickiup Res.	229	USGS Water-Supply Paper 1318	Based on gage data 1926–32
Deschutes River	Wickiup Res. to La Pine State Park, RM 226.7 to RM 208.6	4	OWRD measurements 2/96	
Fall River	Headwaters springs to gage at RM 5	119	OWRD measurements 2/96	Entire flow from springs
Fall River	Gage to mouth, RM 5 to RM 0.4	-7	OWRD measurements 2/96	
Deschutes River	Near Fall River, RM 208.6 to RM 199.7	24	OWRD measurements 2/96	
Deschutes River	Peters Ranch to Camp Abbott Bridge, RM 191.5 to RM 189	271	OWRD gage data for stations 14063800 and 14064000	Period of record 1945 to 1953, includes flow of Spring River

Table 7. Estimated stream gains and losses due to ground-water exchange, upper Deschutes Basin, Oregon.—Continued

[RM, river mile; ft^3/s, cubic feet per second; OWRD, Oregon Water Resources Department; USGS, U.S. Geological Survey; Res., reservoir; NW, northwest; OSU, Oregon State University]

Stream Name	Reach (river mile)	Estimated gain (+) or loss (-) (ft^3/s)	Data source	Remarks
Deschutes River	Camp Abbott Bridge to Benham Falls, RM 189 to RM 181.4	-24	OWRD and USGS gage data for stations 14064000 and 14064500	Period of record 1945 to 1953
Deschutes River	Benham Falls to below Bend, RM 181.4 to 164.4	-89	USGS and OWRD gage data for the river and diversions	Period of record 1945 to 1995
Tumalo Creek	Entire drainage above gage at RM 3.1	68	Statistical summary of gage 14073001 (Moffatt and others, 1990)	Mean August–September discharge, 1924 to 1987, does not include City of Bend diversion
Tumalo Creek	RM 2.3 to RM 0.3	-0.24	OWRD measurements 8/94	Measurements made at very low flow conditions
Deschutes River	Below Bend to Odin Falls Ranch, RM 164.4 to RM 138.0	6.5	OWRD measurements 5/94	Gain may decrease during summer and fall, may be irrigation return flow
Deschutes River	Odin Falls Ranch to NW Riffle Road, RM 138.0 to RM 130.5	17.0	OWRD measurements 5/94	Gain may be irrigation return flow
Deschutes River	Riffle Road to Culver gage, RM 130.5 to RM 120.0	305	OWRD measurements 5/94	
Indian Ford Creek	Upstream from RM 10.7 at Black Butte Ranch	6.1	OWRD measurements 2/94–4/94	
Indian Ford Creek	Black Butte Ranch to mouth, RM 10.7 to RM 0.8	-6.1	OWRD measurements 2/94–4/94	Stream dry at RM 0.8
Squaw Creek	Entire drainage above gage at RM 26.8	65	Statistical summary of gage 14075000 (Moffatt and others 1990)	Mean September discharge 1906 to 1987, may be influenced by glacial melt
Squaw Creek	Near McKinney Butte, RM 19 to RM 16.5	6.6	OWRD measurements 4/94	Discharge from springs
Squaw Creek	McKinney Butte to Alder Springs, RM 16.5 to RM 1.7	0.85	OWRD measurements 4/94	
Squaw Creek	Alder Springs to confluence RM 1.7 to RM 0	94	OWRD measurements 4/94 and 5/94 (at mouth)	
Crooked River	Terrebonne to Trail Crossing, RM 27.6 to 20.4	13.1	OWRD measurements 6/94	
Crooked River	Trail Crossing to Osborne Canyon, RM 20.4 to 13.8	70	OWRD measurements 6/94	
Crooked River	Osborne Canyon to Opal Springs gage, RM 13.8 to RM 6.7	1,006	OWRD measurements 6/94	

Table 7. Estimated stream gains and losses due to ground-water exchange, upper Deschutes Basin, Oregon.—Continued

[RM, river mile; ft^3/s, cubic feet per second; OWRD, Oregon Water Resources Department; USGS, U.S. Geological Survey; Res., reservoir; NW, northwest; OSU, Oregon State University]

Stream Name	Reach (river mile)	Estimated gain (+) or loss (-) (ft^3/s)	Data source	Remarks
Metolius River	Headwaters to Allingham Ranger Station (gage site) at RM 38.1	257	Alexander and others (1987, p. 215); data for gage 14088500 (USGS Water-Supply Paper 1318)	Estimated by using data from different time periods: 9/85 measurements and gage data from 1911 to 1917.
Suttle Lake	Lake above gage at outlet	31	Statistical summary of gage 14088000 (Moffatt and others, 1990)	Mean September flow, 1918 to 1987
Lake Creek	Suttle Lake to mouth	36	Alexander and others (1987, p. 215) and Lake Creek gage data	9/85 measurements, includes about 0.5 mile of Metolius River
First Creek	Upper part of drainage	1.5	OWRD measurements 1992–94	
Jack Creek	Upper part of drainage	46	OWRD measurements 1992–94	
Canyon Creek	Entire drainage above about RM 0.5	60	OWRD measurements 1992–94	
Abbot Creek	Entire drainage above about RM 1.5	12	OWRD measurements 1992–94	
Candle Creek	Entire drainage above about RM 2	73	OWRD measurements 1992–94	
Metolius River	Allingham Ranger Station (RM 38.1) to gage near Grandview (RM 13.6) including lower parts of tributary drainages	724	OWRD measurements 1992–94, USGS gage data	Gain based on OWRD measurements and mean August discharges for gages. Most inflow occurs above Jefferson Creek (RM 28.8)
Lake Billy Chinook	Reservoir encompassing confluence of the Deschutes, Crooked, and Metolius Rivers	379–461	USGS gage data and Bolke and Laenen (1989)	Figure uncertain due to bank storage effects. Evaporation is estimated at 20 to 25 ft^3/s based on 1997 evaporation data from OSU Agricultural Experiment Station at Madras.
Deschutes River	Round Butte Dam to Lake Simtustus, RM 109.9 to RM 108.5	200	Bolke and Laenen (1989)	
Lake Simtustus	Reservoir on the Deschutes River extending from RM 108.5 to RM 102.8	51	Bolke and Laenen (1989)	Figure does not account for evaporation
Deschutes River	Pelton Dam to Regulator Dam, RM 102.8 to RM 100.1	80	Bolke and Laenen (1989)	
Deschutes River	Regulator Dam to below Campbell Creek, RM 100.1 to RM 97.2	53	Bolke and Laenen (1989)	
Deschutes River	Below Campbell Creek to Dry Creek, RM 97.2 to RM 91.8	28	Bolke and Laenen (1989)	No significant gains from this point downstream in study area

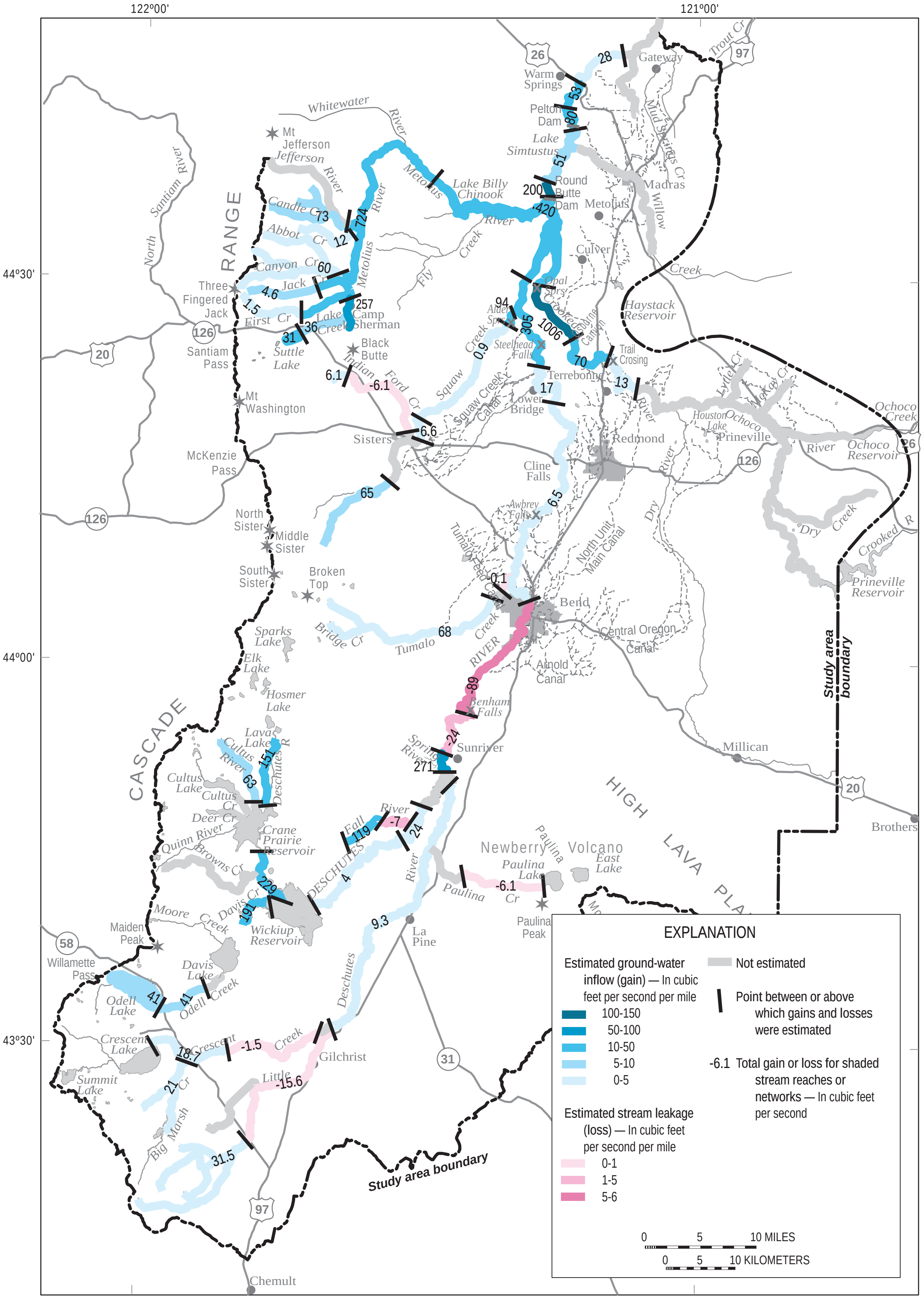

Figure 12. Estimated gain and loss flux rates and net gains and losses for selected stream reaches in the upper Deschutes Basin, Oregon.

Streams typically carry sediment suspended in the water column and along the bottom. Over long periods of time, these materials can infiltrate the openings and essentially seal them, greatly reducing the permeability of the streambed. This process is likely particularly important in streams, such as those in most of the Deschutes Basin, that flow in canyons and do not meander and, therefore, do not periodically establish new channels. Irrigation canals lose more water than streams over a given length. This is because canals are much younger features and have had much less time to be sealed by sediment, and possibly because canal water typically carries very little suspended sediment. Even though the amount of water lost from streams to the ground-water system is only a fraction of the amount that flows from the ground-water system to streams, stream leakage is still an important source of recharge in certain areas.

Leakage from streams, lakes, and reservoirs recharges the ground-water system in some areas in the southern part of the basin. Some of the high lakes, such as Hosmer Lake and Elk Lake (fig. 1) are essentially ground-water fed, and their leakage represents little, if any, net ground-water recharge. Others, such as Sparks and Devils Lakes, are fed at least in part by perennial streams. The net ground-water recharge from these lakes is unknown, but much of it likely emerges as springflow in the Deschutes River and tributaries above Crane Prairie Reservoir.

Crane Prairie Reservoir also loses water through leakage to the ground-water system. This is the only reservoir in the southern part of the basin for which sufficient gages have been operated to allow a good estimate of seepage losses. The average loss from Crane Prairie Reservoir between 1939 and 1950 was computed to be 60,000 acre-ft/yr, or about 83 ft^3/s (U.S. Geological Survey, 1958). A more detailed analysis indicated that the leakage ranges from about 30 to 135 ft^3/s, depending on the stage of the reservoir (Robert F. Main, OWRD, written commun., 1999). Some of this loss probably returns to the Deschutes River through springs within about 3 or 4 miles below Crane Prairie Dam, along what is now an arm of Wickiup Reservoir. It is probable, however, that some of this water contributes to the regional ground-water flow system.

The water budget of Wickiup Reservoir is not as well understood as that of Crane Prairie Reservoir. Although the major streams entering Wickiup Reservoir are gaged, there is substantial spring flow into the western parts of the reservoir along the Deschutes River and Davis Creek. A comparison of annual mean gaged inflow and outflow from Wickiup Reservoir from 1939 to 1991 showed that annual mean net spring flow into the reservoir from the west ranged from 308 to 730 ft^3/s and averaged 486 ft^3/s. This value does not include evaporation, which is considered negligible. This inflow rate varies with climatic conditions and apparently with the stage-dependent losses from Crane Prairie Reservoir (Bellinger, 1994). Although there is net inflow to the reservoir, there is seepage from the reservoir as well. Sinkholes develop periodically, into which large amounts of water drain. Sinkholes apparently have been less of a problem since the early 1960s (Bellinger, 1994). The average rate of seepage from Wickiup Reservoir is unknown, but it is probably not more than a few tens of cubic feet per second.

Seepage runs indicate some losses along the Little Deschutes River as it flows through the La Pine subbasin (table 5). Most of the measured losses are small, 1 to 3 ft^3/s, and are within the measurement error of the 30 to 60 ft^3/s streamflow rates. Measured losses between Gilchrist and Crescent Creek, ranging from 11 to 14.4 ft^3/s, are sufficiently large with respect to measurement error to be considered meaningful. The Little Deschutes River crosses lava flows of Crescent Butte Volcano along this reach and it is likely that water is being lost into permeable lava. Much of this water likely returns to the river in gaining reaches not far downstream. A seepage run on Crescent Creek, a tributary to the Little Deschutes River, indicated a 1.5 ft^3/s loss in the lower 18 miles. This loss is small compared to the flow, approximately 33 ft^3/s, and is within the measurement error.

Paulina Creek, a tributary to the Little Deschutes River that flows down the west flank of Newberry Volcano, had measured net losses of approximately 2 to 6 ft^3/s between river mile 13, at its source at the outlet of Paulina Lake, and river mile 5.2, where it flows onto the floor of the La Pine subbasin (Morgan and others, 1997). This loss accounted for roughly 20 to 40 percent of the flow of Paulina Creek at the times the seepage runs were made.

Seepage runs indicate that, with the exception of the reservoirs discussed previously, the Deschutes River has no significant losing reaches upstream of its confluence with the Little Deschutes River. Downstream from the confluence, gaging-station data indicate significant losses occur along the reach extending from the community of Sunriver downstream to Bend. Comparison of flow measured at a gage operated from 1945 to 1953 at the Camp Abbott Bridge with the flow at the Benham Falls gage about 10 miles downstream indicates that this reach of the river lost an average of about 24 ft^3/s during that period (Oregon Water Resources Department, 1965). The loss, as calculated using monthly mean flow, is variable and weakly correlated with flow (correlation coefficient = 0.40).

The Deschutes River loses an average 83 ft^3/s between Benham Falls and the gage site below Lava Island about 7.5 miles downstream, based on the period of record from 1945 to 1965. The loss in flow along this reach ranged from -10 ft^3/s (a slight gain) to 236 ft^3/s and is fairly well correlated with flow (correlation coefficient = 0.74) (fig. 13). The wide range of these values is likely due to measurement error of the stream gages and of the gage on a diversion used in the loss calculation. The rate of leakage in this reach far exceeds that of any other losing stream reach in the upper Deschutes Basin.

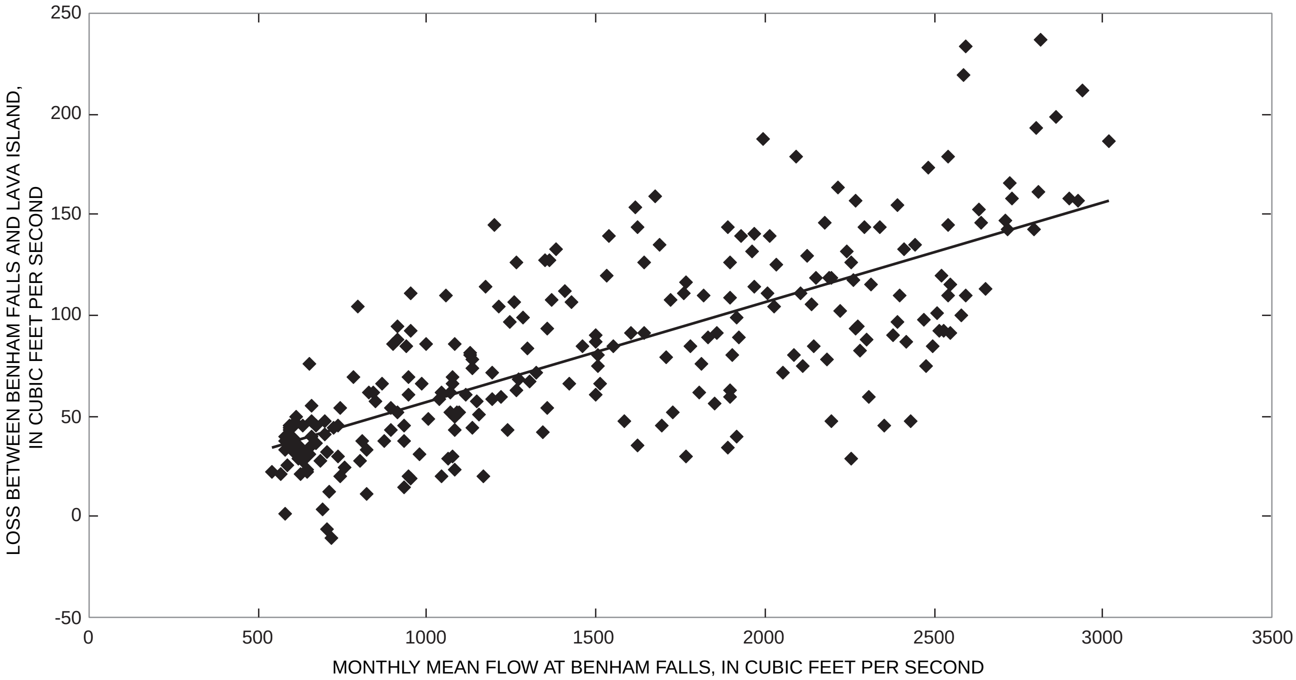

Figure 13. Relation between monthly mean losses along the Deschutes River, Oregon, between Benham Falls and Lava Island, and flow at Benham Falls.

The leakage in this area is likely into very young, highly permeable lava flows from Lava Butte that diverted the river and now form much of the east bank and some of the falls along this reach. Stream losses between Camp Abbott Bridge and Lava Island far exceed losses anywhere else in the upper Deschutes Basin and are an important source of recharge.

USGS and OWRD stream-gage data from 1945 to 1965 indicate that average stream losses between the gage below Lava Island and the gage below Bend are small, about 4.0 ft^3/s. The difference in flow along this reach ranged from a 68 ft^3/s gain to a 72 ft^3/s loss, and shows no correlation with flow. The wide range in values is likely due to measurement error of the stream gages and of the gages on five diversions used in the calculations.

Calculated losses along the two reaches of the Deschutes River described above, which total 87 ft^3/s, are based on a period of record from 1945 to 1965. Losses along the two separate reaches after 1965 cannot be calculated because the gage below Lava Island ceased operation. Losses can be calculated, however, for the entire reach from Benham Falls to Bend for a much longer period. The average loss between Benham Falls and Bend, based on monthly mean flows from 1945 to 1995, is 89 ft^3/s. This agrees favorably with the sum of losses calculated for the subreaches for the shorter period of record.

Information on stream losses along the Deschutes River from Bend downstream to Lower Bridge is from OWRD seepage runs (Kyle Gorman, OWRD, written commun., 1995) (table 5); gage data are insufficient for evaluating losses along this reach. Seepage runs indicate that there are two areas between Bend and Lower Bridge where the Deschutes may lose a small amount of water (table 5). These areas are between river miles 154.5 and 146.8, near Awbrey Falls, and between river miles 145.3 and 143.2, near Cline Falls. Losses in both these areas are about 10 ft^3/s, and were measured when flows ranged from 30 to 50 ft^3/s. Not far downstream from both of these losing reaches, the river gains comparable amounts of water, implying that water lost from the river along this section apparently returns to the surface not far downstream. These seepage runs were done during periods of very low streamflow and may not reflect losses at higher flow rates. However, gage data from upstream between Lava Island and Bend suggest that losses may not be flow dependent along this reach. There are no significant losses from the Deschutes River downstream of Lower Bridge.

Stream losses also were measured along Indian Ford Creek (table 5). A series of seepage measurements taken by OWRD during the winter months of 1992 indicate that Indian Ford Creek lost its entire flow (approximately 6 ft^3/s) between the Black Butte Ranch springs, where it originates, and its confluence with Squaw Creek.

No other streams measured in the upper Deschutes Basin showed significant losses. The lower sections of Tumalo and Squaw Creeks showed only minor losses of less than 1 ft^3/s when measured during low flow conditions. Possible losses during higher flow conditions are not known.

Drainage Wells

Storm runoff in urban areas of the upper Deschutes Basin is often disposed of through drainage wells. Drainage wells in this report include both drilled disposal wells and larger diameter, but shallower, drywells, which are usually dug. Runoff disposed of in drainage wells is routed directly to permeable rock beneath the land surface, bypassing the soil zone from which a certain amount of the water would normally be returned to the atmosphere through evaporation or transpiration by plants. Once routed to permeable rock beneath the soil, the runoff percolates downward to recharge the ground-water system.

Although runoff disposed of through drainage wells represents a source of ground-water recharge, the volume of water is very small relative to other sources of recharge in urban areas, such as canal leakage, and minuscule compared to the entire ground-water flow budget. To illustrate this, estimates of the amount of ground-water recharge through drainage wells in Bend and Redmond are presented in this section.

Engineering maps provided by the city of Bend in 1994 show approximately 1,175 drainage wells used for street drains in the city. This number does not include drainage wells on private property, but their distribution is taken to represent the area over which runoff is handled in this manner. There are 163 quarter-quarter sections (40-acre tracts) with at least 1 and as many as 30 drainage wells. The quarter-quarter sections with at least one drainage well compose a total area of just over 10 mi2. To estimate the amount of ground-water recharge from drainage wells, it is necessary to estimate the fraction of the total precipitation that is routed to them.

Runoff routed to drainage wells is that which falls on impervious surfaces and cannot infiltrate the soil naturally. Roofs, driveways, parking lots, and streets are examples of impervious surfaces. The amount of impervious surface relative to the total land area varies with land-use type. Commercial areas, with large roofed structures and expansive parking lots, can be 85 percent impervious (Snyder and others, 1994). Impervious surfaces in residential areas, in contrast, range from 20 percent of the land area, for large lots where yards are big relative to structures and driveways, to 65 percent for small lots (Soil Conservation Service, 1975). A value of 35 percent impervious surface was used for calculations for Bend, based on mapped impervious areas for dominantly residential areas in Portland, Oregon, and Vancouver, Washington (Laenen, 1980, table 1).

Not all of the precipitation that falls on impervious surfaces runs off to drainage wells. A certain amount is evaporated from wetted surfaces and undrained areas such as puddles, and from detention structures. This is known as detention-storage loss. In estimating recharge from drainage wells in the Portland Basin, Snyder and others (1994), using the work of Laenen (1980), estimated that about 25 percent of the precipitation was evaporated in this manner, leaving about 75 percent to run off to drainage wells. Because this value was derived using conditions in western Oregon, it may be low for the Bend area, where conditions are much dryer. A detention-storage loss of 25 percent is used herein with the assumption that if it is too conservative, recharge from drainage wells may be slightly overestimated.

Average recharge from drainage wells in Bend was estimated assuming that runoff from all impervious surfaces in any quarter-quarter section (40-acre tract) with at least one drainage well was disposed of through drainage wells. There are 163 quarter-quarter sections meeting this criteria, with an aggregate area of 10.19 mi^2. Average precipitation in Bend is 11.70 in/yr (period of record 1961 to 1990) (Oregon Climate Service, 1999). Using these figures and assuming that 35 percent of the area is impervious surface and that 25 percent of the precipitation is lost through evaporation, the runoff routed to dry wells is approximately 73 million ft^3/yr, or about 2.3 ft^3/s. This is not a significant source of recharge when compared to canal and stream leakage, which can exceed 20 ft^3/s/mi near Bend.

Similar calculations were done for Redmond using maps provided by the city and aerial photographs taken in 1995. A public-facilities map indicates there are about 30 quarter-quarter sections within Redmond in which there is at least one drainage well, with an aggregate area of 1.88 mi^2. Analysis of 1995 aerial photographs suggests that there may be new residential areas not included in this total, but these represent only a small increase in the total area and are not included in the following calculation. Using the same values as in the analysis for Bend to represent the percentage of impervious area and evaporative losses and an average annual precipitation of 7.83 inches (1961–90), total runoff to drainage wells in Redmond is estimated to be approximately 9 million ft^3/yr, or about 0.28 ft^3/s. As with Bend, this is not a significant source of recharge.

Similar calculations were not carried out for other urban areas in the upper Deschutes Basin. Examples from Bend and Redmond, the most urbanized areas, illustrate that runoff to drainage wells is not an important volumetric component of ground-water recharge.

Although runoff to drainage wells is not volumetrically substantial, it may be significant in terms of water quality. Urban runoff can contain contaminants such as household pesticides and fertilizers, and automotive petroleum products. Runoff routed directly to drainage wells has a direct pathway to the ground-water system, bypassing the soil zone, where natural processes such as filtration, adsorption, and biodegradation may serve to reduce levels of some contaminants.

Interbasin Flow

The final source of recharge to the upper Deschutes Basin regional ground-water system is subsurface flow from adjoining basins. In general, the lateral boundaries of the upper Deschutes Basin study area are considered to be no-flow boundaries. There are, however, two areas where inflow from adjacent areas is probable: along the Cascade Range crest in the Metolius River drainage and in the southeastern part of the study area northeast of Newberry Volcano.

The western boundary of the study area coincides with the topographic crest of the Cascade Range. It is generally considered a no-flow boundary because the ground-water divide is assumed to follow the distribution of precipitation, which generally follows the topography. The isohyetal map of Taylor (1993) shows that in the area of the Metolius River subbasin, the region of highest precipitation occurs west of the topographic crest of the Cascade Range, suggesting that the ground-water divide is also to the west of the topographic divide and that there is likely ground-water flow eastward across the topographic divide. This interbasin flow is also indicated by the hydrologic budget of the Metolius River subbasin. Average ground-water discharge to the Metolius River in the study area above the gage near Grandview is approximately 1,300 ft^3/s. The mean annual recharge from precipitation in the Metolius River subbasin above this point in the study area is estimated to be only about 500 ft^3/s. The difference, 800 ft^3/s, almost certainly comes from subsurface flow from an adjacent basin. The most plausible source for this additional water is the upper Santiam and North Santiam River Basins to the west.

South of Bear Creek Butte, through Millican and the China Hat area, the eastern study-area boundary does not coincide with either a topographic divide or a geologic contact. The region east of this area was not included in the study area because of the lack of subsurface hydrologic information, very low recharge, and distance from the areas of primary concern. Hydraulic-head data, however, indicate there is some flow across this boundary into the study area from the southeast. This flux was estimated using a variety of methods.

The part of the Deschutes Basin east of this boundary is very dry (10 to 15 in/yr precipitation) and has a poorly developed drainage system with no perennial streams. The divide between this part of the Deschutes Basin and the Fort Rock and Christmas Lake Basins to the south is poorly defined and interbasin flow is likely. Miller (1986) states that flow to the Deschutes Basin from the Fort Rock Basin “probably exceeds 10,000 acre-ft/yr,” which equals about 14 ft^3/s. Estimates based on the Darcy equation, using measured head gradients and estimated hydraulic conductivity and aquifer thickness, suggest that the flux into the study area may be as high as 100 ft^3/s. Additional estimates were derived using a water-budget approach. The probable area contributing to the boundary flux was defined using hydraulic-head maps from the Deschutes Basin and the Fort Rock Basin (Miller, 1986). Flux rates were calculated using a range of recharge values from Newcomb (1953), Miller (1986), and McFarland and Ryals (1991). Assuming a contributing area of 648 mi^2 and recharge estimates ranging from 0.5 to 3.0 in/yr, the boundary flux could range from 25 to 145 ft^3/s. If recharge is assumed to be 1.0 in/yr in the contributing area for this boundary flux, the estimated flux rate is about 50 ft^3/s.

Ground-Water Discharge

Ground water discharges from aquifers to streams, to wells, and through evapotranspiration. Discharge to streams is the principal avenue by which water leaves the ground-water system. Discharge can occur to discrete springs or as diffuse seepage through streambeds. Pumping by wells is another avenue by which ground water leaves the ground-water system. In the Deschutes Basin, discharge to wells represents a small fraction of the total ground-water discharge. Evapotranspiration by plants is the third mechanism considered in this report. Most plant water requirements are met by water percolating downward through the soil before it enters the ground-water system. In some areas where the water table is sufficiently shallow to be within the rooting depth of plants, transpiration can occur directly from the ground-water system. This process represents a very small fraction of the total ground-water discharge in the basin. Each of these mechanisms is discussed in more detail in the following sections.

Ground-Water Discharge to Streams

Discharge to streams is the main avenue by which water leaves the ground-water system and is one of the major components of the hydrologic budget. Ground water discharges to streams in areas where the stream elevation is lower than the elevation of the water table in adjacent aquifers. Considerable amounts of ground water can discharge to the streams in this way from regional aquifers with large recharge areas. Streams in which the flow increases due to ground-water discharge are termed gaining streams. The amount of ground water discharging to streams or leaking from streams varies geographically and with time.

Understanding the rates and distribution of ground-water discharge to streams is critical to understanding the ground-water hydrology of an area. The amount and location of ground-water discharge can be determined by measuring streamflow at points along a stream and accounting for tributary inflow and diversions between the points as well as temporal changes in flow. In general, increases in flow from point to point downstream that are not due to tributary inflow are caused by ground water discharging to the stream. Discharge can occur either at discrete locations such as springs or as diffused seepage through the streambed.

Stream-gage data can be particularly useful for estimating ground-water discharge. Gages on spring-fed streams, such as Fall River, measure ground-water discharge directly. Data from pairs of gages operated concurrently along a stream can be compared to estimate ground-water inflow between the gages as long as tributary inflow and diversions can be accounted for. Late summer and early fall flows in some streams are essentially entirely ground-water discharge (base flow). Therefore, annual low flows at certain stream gages can provide reasonable estimates of ground-water discharge.

Estimates of ground-water discharge to major streams in the upper Deschutes Basin are provided in table 7. These estimates are based on seepage runs and stream-gage data as well as other miscellaneous measurements. Unless otherwise noted, the values in table 7 represent approximate long-term average conditions.

Geographic Distribution of Ground-Water Discharge to Streams

There are three main settings in the upper Deschutes Basin where substantial amounts of ground-water discharge to streams: the southern part of the basin in and near the margin of the Cascade Range, the Metolius Basin adjacent to the Cascade Range, and the area surrounding the confluence of the Deschutes, Crooked, and Metolius Rivers extending downstream to about Pelton Dam (fig. 12). This latter area is referred to as the “confluence area” in this report.

Ground water constitutes a large proportion of the flow in many streams in and along the margin of the Cascade Range in the southern part of the basin (table 7). Ground water constitutes virtually the entire flow of some of these streams, such as Fall River. Such streams are recognized by the presence of source springs, lack of tributary streams, and flows that are very constant relative to other streams. Hydrographs of mean monthly flows (fig. 14) illustrate the differences between streams in which ground water is the dominant source and those in which surface run-off is the dominant source. Fall, Cultus, and Quinn Rivers, and Browns Creek all show relatively little variation in flow throughout the year indicating that they are not greatly affected by surface runoff and that ground water provides most of their flow. In contrast, Squaw, Big Marsh, Cultus, and Deer Creeks, and the Deschutes River (measured at the gage below Snow Creek just above Crane Prairie Reservoir) all show substantial increases in flow during spring due to runoff, indicating that their flow is dominated, or at least affected, by surface runoff.

Some of these runoff-dominated streams, such as the Deschutes River, have substantial flow even during the driest months of the year, indicating that ground-water discharge constitutes an important part of the flow. Others, such as Cultus and Deer Creeks, nearly cease to flow in the driest months of the year, indicating that ground-water discharge is only a minor part of their total flow. Temporal variations in ground-water discharge are discussed in more detail in a later section of the report.

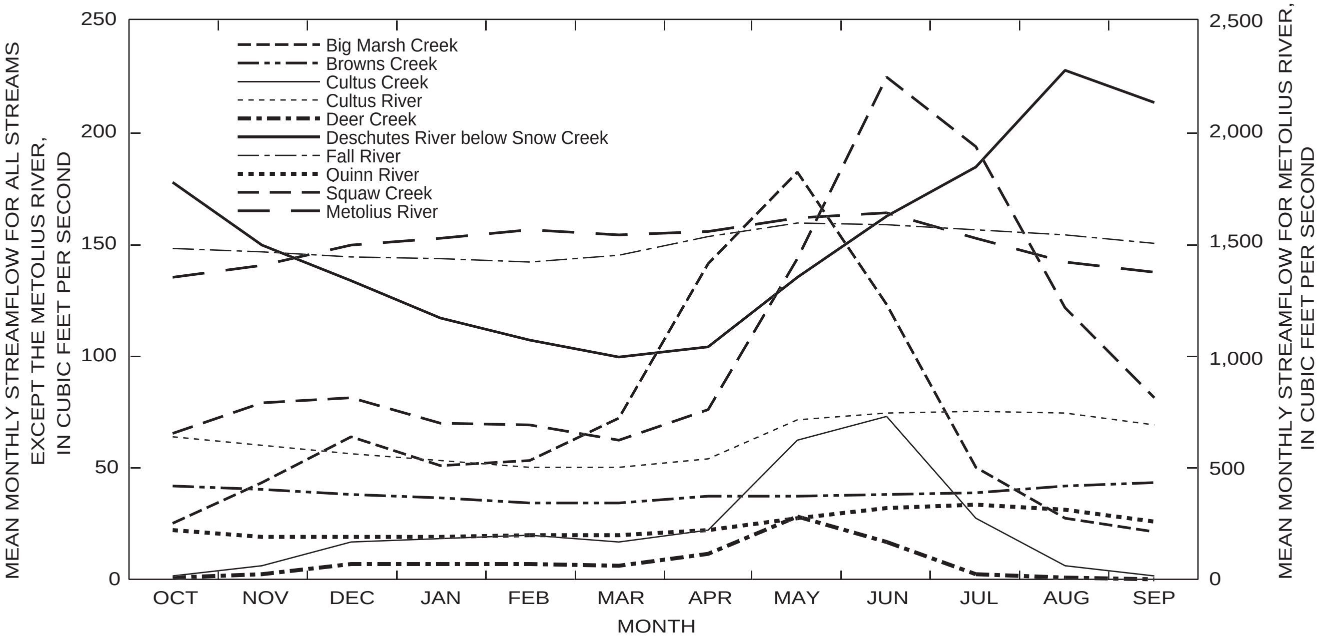

Figure 14. Mean monthly flows of selected nonregulated streams in the upper Deschutes Basin, Oregon.

The Metolius River drainage is the second region of significant ground-water discharge in and along the margin of the Cascade Range (fig. 12, table 7). The Metolius River drainage comprises numerous streams emanating from the Cascade Range, many of which are spring fed and others that are probably runoff dominated. The only long-term stream gage on the Metolius River is low in the drainage just above Lake Billy Chinook (this gage is officially referred to as being near Grandview, an abandoned town site). Although this gage represents a large drainage area that encompasses both spring-fed and runoff-dominated streams, it warrants analysis because of the large volume of ground water that discharges in the Metolius River drainage. Two tributary streams, Jefferson Creek and Whitewater River, carry glacial runoff from Mt. Jefferson and have late-season flows not entirely attributable to ground-water discharge.

A hydrograph of the monthly mean flow of the Metolius River near Grandview from 1922 to 1997 (fig. 15) clearly shows transient runoff events caused by spring snowmelt and large storms. During the late summer, however, when surface runoff is minimal, the flow of the Metolius is largely ground-water discharge. These late-summer flows are relatively large, reflecting the large amount of ground-water discharge. The lowest mean monthly flow occurs during October. The mean October flow of the Metolius River near Grandview for the period 1912–87 was 1,350 ft^3/s (Moffatt and others, 1990). This amount includes the flow of Jefferson Creek and Whitewater River, which may include late-season glacial melt, but the contribution from these streams is relatively small. The mean October flow of Jefferson Creek was 77 ft^3/s during the period 1984–98 and that of Whitewater River was 53 ft^3/s during the period 1983–98. Depending on the amount of the mean October flow of these streams that is glacial in origin, the mean October flow of the Metolius River near Grandview that is derived from ground-water discharge is between 1,220 and 1,350 ft^3/s.

A variety of regional geologic factors controls the location of ground-water discharge to streams and springs in and along the margins of the Cascade Range. Many large spring areas and gaining stream reaches, such as Fall and Spring Rivers, coincide with the boundary of the La Pine and Shukash structural basins. The low-permeability basin-filling sediments likely divert ground water toward the surface by acting as an impediment to subsurface flow.

Geologic structure can also influence ground-water discharge in and along the margins of the Cascade Range. The tremendous amount of ground water discharging to the upper Metolius River and its tributaries is undoubtedly due in large part to the major fault system along the base of Green Ridge (fig. 4). Green Ridge is a 20-mile long escarpment that marks the eastern margin of a north-south trending graben into which the Cascade Range in that area has subsided (Allen, 1966; Priest, 1990). Vertical movement along this fault system is estimated to be over 3,000 ft (Conrey, 1985). The fault system may influence ground-water discharge in two ways. First, elevation of the valley on the downthrown side of the fault system is anomalously low when compared to surrounding terrane a similar distance from the Cascade Range. Low-elevation areas commonly are regions of ground-water discharge. Second, the fault itself likely impedes eastward movement of ground water flowing from the Cascade Range, forcing ground water to discharge to the river. The impediment to eastward ground-water movement could be due to low-permeability crushed or sheared rock along the fault planes or the juxtaposition of permeable strata on the west side of the fault system against low-permeability strata on the east. Analysis of carbon isotope data (James and others, 1999) suggests that the water discharged from the Metolius River springs includes a component of deep regional ground water, implying that there is vertical permeability locally along the escarpment.

Local geology also affects the location of ground-water discharge. Many springs occur along the edges or ends of Quaternary lava flows. Ground water emerges at these locations because saturated permeable zones in or at the base of the lava flows intersect land surface. Some springs, such as those at the upper end of Davis Creek, emerge in buried stream channels at the ends of intracanyon lava flows.

The total average amount of ground water discharging to streams in and along the margin of the Cascade Range in the study area is estimated to be approximately 2,600 ft^3/s. This includes discharge to streams in the southern part of the study area, in the Tumalo and Squaw Creek drainages, and in the Metolius River drainage (table 7). Approximately one-half of this amount discharges in the Metolius River drainage.

The third major setting in which ground water discharges to streams is the region around the confluence of the Deschutes, Crooked, and Metolius Rivers and extending downstream to the vicinity of Pelton Dam. Russell (1905, p. 88) provides an early description of ground-water inflow in this region:

> Crooked River at Trail Crossing, at the time of my visit in early August [1903], had shrunk to a brook of tepid, muddy, and unwholesome water, across which one could step dry-shod from stone to stone. Its volume, by estimate, was not more than 2 cubic feet per second.... On descending the canyon about 12 miles lower down its course I was surprised to find a swift-flowing, clear stream of cool, delicious water, by estimate 100 feet wide and 3 feet deep, with a volume of not less than 300 cubic feet per second. This remarkable renewal or resuscitation of a stream in an arid land is due to the inflow of Opal and other similar springs.

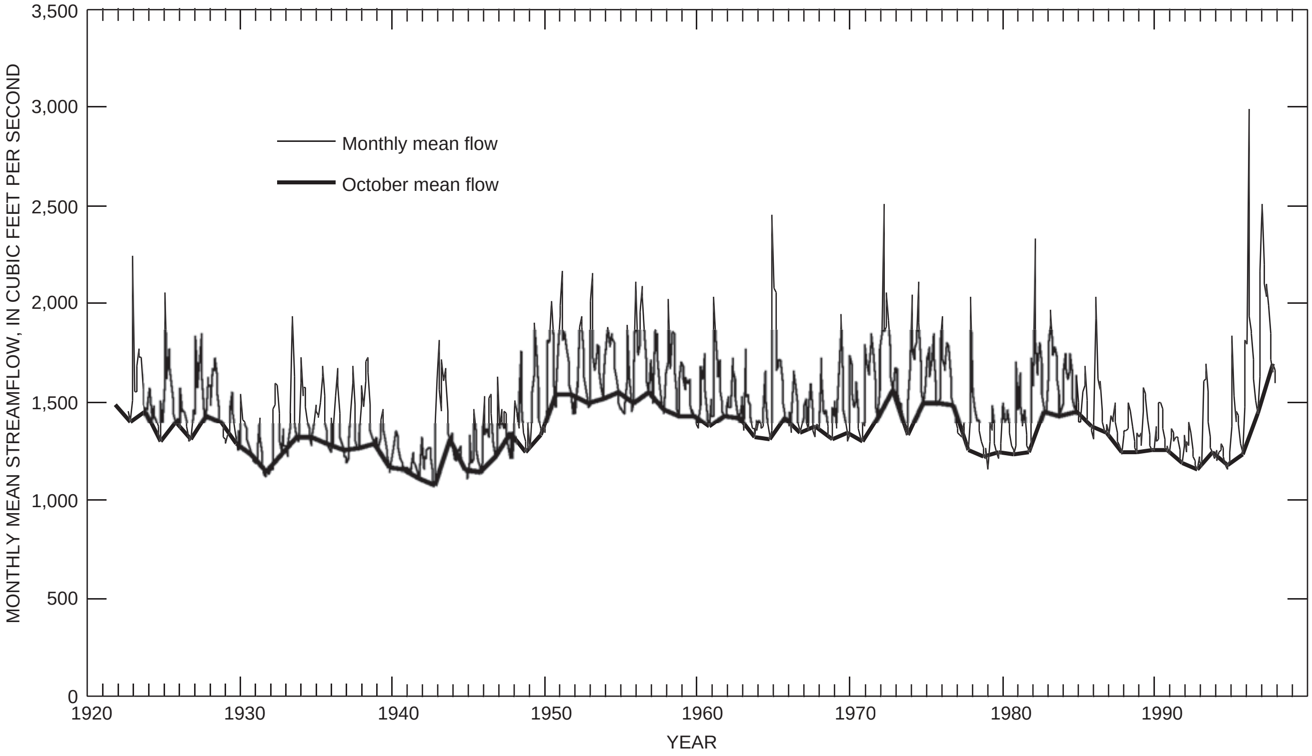

Figure 15. Monthly mean flow of the Metolius River near Grandview. (The line connecting the October mean flows approximates ground-water discharge.)

Stearns (1931) also recognized the large amount of ground water discharging to streams in the area while investigating the geology and hydrology of the middle Deschutes Basin for potential dam sites. Stearns used stream-gage data to conservatively estimate ground-water inflow to the lower Crooked River between Trail Crossing and the gaging station near Culver (now under Lake Billy Chinook) to be 950 ft^3/s. He also used gage data to estimated ground-water inflow to the Deschutes River between Bend and Madras at about 600 ft^3/s. These numbers are generally consistent with modern estimates when the effects of irrigation development and of Round Butte Dam are considered.

Ground-water discharge to the lower Crooked River and middle Deschutes River was estimated from OWRD seepage runs (fig. 12, table 5). Ground-water discharge to the lower Crooked River between Terrebonne and the gage below Opal Springs was approximately 1,100 ft^3/s in June 1994 (fig. 16, table 5). Most of this inflow entered the Crooked River below Osborne Canyon, about 7 miles upstream from the gaging station below Opal Springs. The Deschutes River gained approximately 400 ft^3/s along the 10-mile reach above the gaging station near Culver, just above Lake Billy Chinook, during seepage runs in May 1992 and May 1994 (fig. 17, table 5). About 300 ft^3/s of

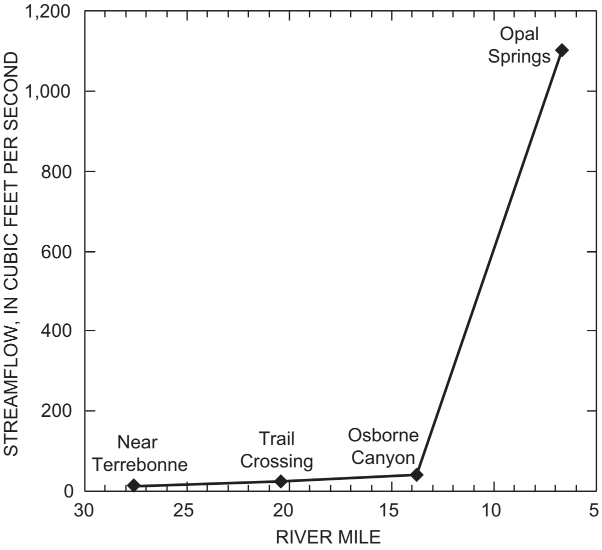

Figure 16. Gain in flow of the lower Crooked River, Oregon, due to ground-water discharge between river miles 27 and 7, July 1994.

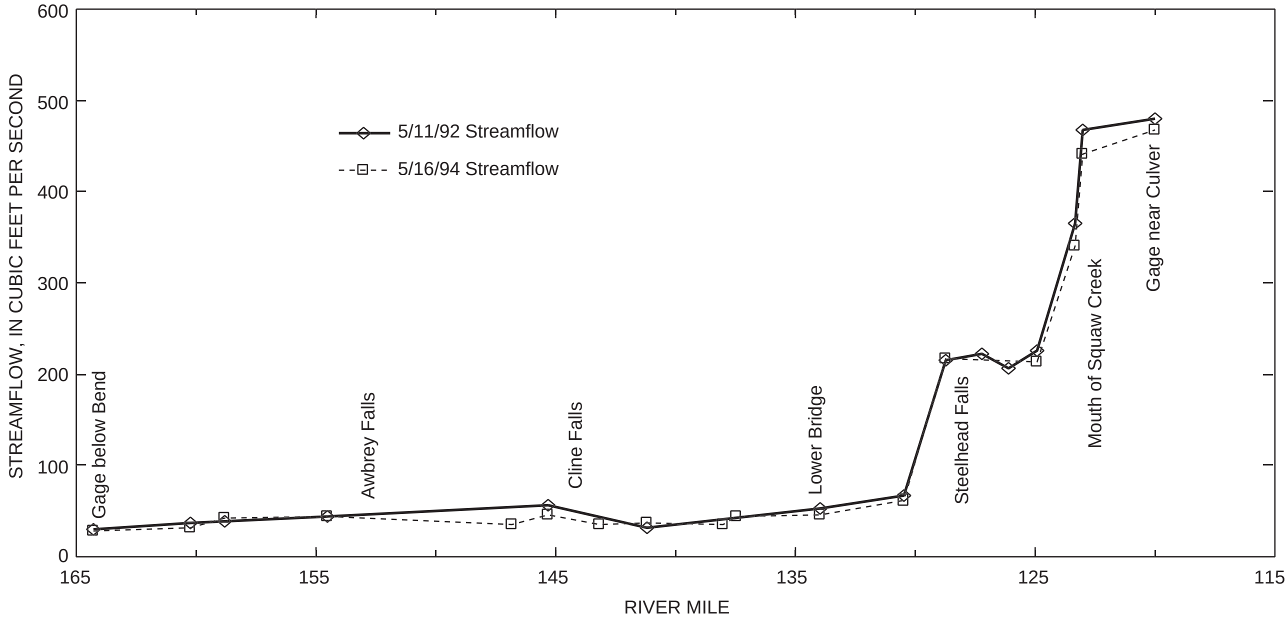

Figure 17. Gain in flow of the Deschutes River, Oregon, due to ground-water discharge between river miles 165 and 120, May 1992 and May 1994. (Some of the gain is due to ground-water discharge along the lower 2 miles of Squaw Creek.)

this gain was from ground-water discharge directly to the Deschutes River, and the remaining 100 ft^3/s was mostly from ground-water discharge to lower Squaw Creek near its confluence with the Deschutes River. A seepage run made along Squaw Creek in April 1994, combined with data from the seepage run along the Deschutes River a month later, showed Squaw Creek gaining approximately 94 ft^3/s from springflow in the lower 1.7 miles from Alder Springs to the confluence (table 7).

The ground-water discharge estimates from seepage runs on the lower Crooked River, Deschutes River, and Squaw Creek are probably conservative estimates of long-term mean annual ground-water discharge. The seepage runs were conducted after a period of several relatively dry years. The monthly mean streamflows for the months during which the seepage runs were conducted were low compared to the long-term mean monthly flows (Hubbard and others, 1993, 1995). Temporal variations in ground-water discharge are discussed in a later section.

Ground-water inflow to Lake Billy Chinook, estimated from stream-gaging-station data, is roughly 420 ft^3/s (the middle of the range in table 7). From Round Butte Dam downstream to Dry Creek at river mile 91.8 (about 2.5 miles below Shitike Creek), the Deschutes River gains about 400 ft^3/s from ground-water inflow (table 7). There is no significant ground-water inflow directly to the Deschutes River downstream from this point. The total amount of ground water discharging to the Deschutes and Crooked Rivers in the area extending from about 10 miles above Lake Billy Chinook to Dry Creek is approximately 2,300 ft^3/s. This is probably a conservative estimate for the reasons previously discussed.

The ground-water discharge estimate in the confluence area (2,300 ft^3/s) cannot be simply added to the discharge estimate for streams emanating from the Cascade Range (2,600 ft^3/s) to estimate average net ground-water discharge to streams in the basin. The resulting value exceeds the total estimated ground-water recharge for the entire upper Deschutes Basin. This is because the streams to which ground water discharges in the upper basin lose some of that water (as much as 600 ft^3/s) back to the ground-water system through stream and canal leakage. This water discharges once again in the confluence area. Therefore, a fraction of the ground water discharged in the confluence area has entered and been discharged from the ground-water system twice.

Ground-water discharge in the confluence area is controlled primarily by geology. Sceva (1960), in a report prepared for the Oregon Water Resources Board, was the first to describe the influence of the geology on regional ground-water flow and discharge. His basic conceptual model was largely corroborated by subsequent data collection and analysis. In a later report he states: "A barrier of rocks having a low permeability transects the Deschutes River Basin near Madras. This barrier forces all of the ground water to be discharged into the river system... (Sceva, 1968, p. 5)."

The Deschutes Basin is transected by a broad ridge composed of the John Day Formation, a rock unit of very low permeability that extends, with varying degrees of exposure, from the Gray Butte area north to the Mutton Mountains (outside and to the northwest of the study area) and east into the John Day Basin (fig. 4). This broad ridge is part of a regional uplift extending from central to northeastern Oregon known as the Blue Mountain anticline (Orr and others, 1992).

The John Day Formation in this area consists of tuffaceous claystone, air-fall and ash-flow tuffs, and lava flows (Robinson and others, 1984). The ridge of the John Day Formation represents an ancient upland that formed the northern and eastern boundary of the basin into which the permeable Deschutes Formation was deposited. North of Madras, the Deschutes Formation, through which most regional ground water in the upper basin moves, becomes increasingly thin and eventually ends. Because the John Day Formation has such low permeability, ground water cannot move farther north in the subsurface and is forced to discharge to the Crooked and Deschutes Rivers, which have fully incised the Deschutes Formation (fig. 18). Analysis of stream-gaging data shows that there is no significant ground-water discharge to the Deschutes River downstream from the area where the John Day Formation forms the walls of the river canyon.

Temporal Variations in Ground-Water Discharge to Streams

Ground-water discharge to streams not only varies from place to place, but varies with time as well. The rate of ground-water discharge varies on many time scales, but for this study, annual and decadal time scales are examined. Annual discharge variations are driven by the seasonal variations in precipitation and ground-water recharge. Decadal variations in ground-water discharge in the Deschutes Basin are driven by variations in precipitation and recharge due to climate cycles. Longer-term variations in discharge, occurring over many decades, can be caused by long-term climate trends. Ground-water discharge variations at all of these time scales can be influenced by human activity. Temporal variations in ground-water discharge in the basin are discussed in the following paragraphs.

Virtually all the data on temporal variations in ground-water discharge were derived from stream gages, where continuous records of stream discharge were recorded (fig. 11). Data from stream gages are useful for estimating ground-water discharge only in certain circumstances. Regulation of streamflow at upstream dams or other control structures precludes the use of some gages for estimating ground-water discharge. If the gage is at a location where it is known that the streamflow is virtually entirely from ground-water discharge, such as with spring-fed streams like Fall River, then the gage provides a continuous direct measurement of ground-water discharge. In such cases, the gage can provide information on variations in ground-water discharge at many time scales ranging from daily to long term. In other circumstances, such as along the lower Crooked River at Opal Springs, streamflow can only be assumed to represent ground-water discharge during the driest months of the year when surface runoff from upstream is negligible compared to known inflow from springs. In cases such as this, the gage cannot be used to evaluate seasonal variations in ground-water discharge, but can provide information on year-to-year variations. In some circumstances, a set of gages operated concurrently on a stream can be used to estimate ground-water inflow to the stream between the gages as long as there is no unmeasured tributary inflow or diversion along the intervening reach.

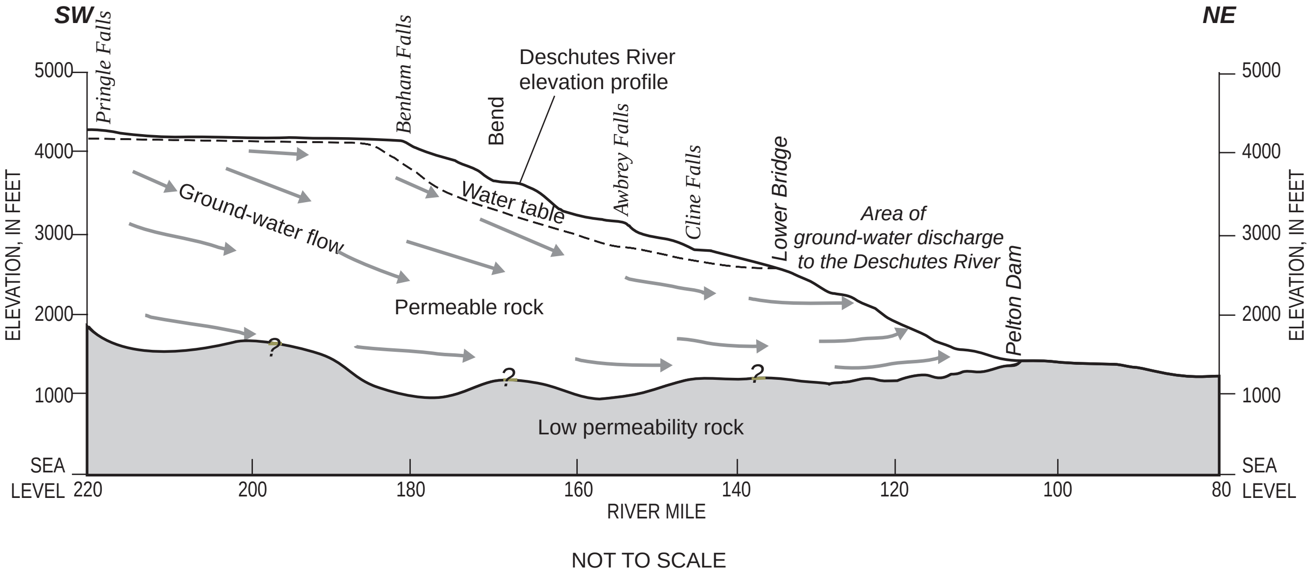

Figure 18. Effect of geology on ground-water discharge along the Deschutes River, Oregon, upstream of Pelton Dam.

Stream-gage data suitable for estimating temporal variations in ground-water discharge are available for only a few locations in the upper Deschutes Basin because stream gages are typically located and operated for other reasons. However, the main ground-water discharge settings are represented in the available data.

Stream-gage data are available for a number of small spring-fed streams along the margin of the Cascade Range in the southern part of the basin, including Cultus, Quinn, and Fall Rivers, and Browns Creek. The flow in these streams is almost entirely ground-water discharge, as indicated by constant flow throughout the year (fig. 14). The gages on these streams provide an approximate continuous measure of ground-water discharge. The flow in these streams does vary seasonally, and they do exhibit annual peaks in flow. The magnitude of the peak flow is attenuated and the timing of the peak flow is delayed when compared with runoff-dominated streams such as Cultus, Deer, and Big Marsh Creeks (fig. 14). The differences between ground-water- and surface-water-dominated streams is apparent in the statistics of their mean monthly flows (table 8). The range in mean monthly flows for surface-water-dominated streams is over 200 percent of their mean annual flow. The months with the highest mean flows for surface-water-dominated streams are May and June. The range in mean monthly flows for ground-water-dominated streams, in contrast, is only 11 to 58 percent of their mean annual flows, and the high flow may occur any month from May through September. The peaks in flow seen in ground-water-dominated streams are caused by the same snowmelt events that provide peak discharge to runoff-dominated streams. Because the water must percolate through the soil and move through the subsurface before discharging to spring-fed streams, the peaks in flow are attenuated and delayed.

Table 8. Statistical summaries of selected non-regulated streams in the upper Deschutes Basin, Oregon

[Source: Moffatt and others, 1990; ft^3/s, cubic feet per second]

Station name	Station number	Period of record	Mean annual flow (ft^3/s)	Highest mean monthly flow (ft^3/s)	Month of highest mean monthly flow	Lowest mean monthly flow (ft^3/s)	Month of lowest mean monthly flow	Variation as percentage of mean annual flow
Deschutes River below Snow Creek	14050000	1937–87	151	227	August	99	March	85
Cultus River above Cultus Creek	14050500	1923–87	63	75	July	50	February–March	40
Cultus Creek above Crane Prairie Reservoir	14051000	1924–62	22	73	June	1.2	October	326
Deer Creek above Crane Prairie Reservoir	14052000	1924–87	7.5	28	May	0.2	September	371
Quinn River near La Pine	14052500	1938–87	24	33	July	19	November–January	58
Browns Creek near La Pine	14054500	1923–87	38	43	September	34	February–March	24
Fall River near La Pine	14057500	1938–87	150	159	May	142	February	11
Big Marsh Creek at Hoey Ranch	14061000	1912–58	72	182	May	21	September	224
Squaw Creek near Sisters	14075000	1906–87	105	224	June	62	March	154
Metolius River near Grandview	14091500	1912–87	1,500	1,640	June	1,350	October	19

The time lag between the annual peak snowmelt and the peak in the flow of these spring-fed streams is proportional to the degree of attenuation of annual flow peak; in other words, the more subdued the peak flow, the longer the time lag (Manga, 1996). A mathematical model for ground-water-dominated streams in the Cascade Range developed by Manga (1997) relates the degree of attenuation and the time lag of the peak streamflow to the generalized geometry and hydraulic properties of the aquifers feeding the stream. In Manga's model, the annual recharge pulse caused by snowmelt is essentially diffused along the length of the aquifer causing the attenuation and delay in the peak flow. This suggests that streams fed by aquifers with large areas are likely to have more uniform flow and a longer delay between recharge events and peak flows when compared to streams fed by aquifers with small capture areas.

The spring-fed streams in the southern Deschutes Basin exhibit decadal flow variations in addition to annual variations. Individual peak periods on Fall River, for example, are roughly 5 to 14 years apart. Decadal variations in annual mean discharge can be substantial. Stream-gage data show that between 1939 and 1991 the annual mean flow of Fall River varied from 81 to 202 ft^3/s and the annual mean flow of Cultus River ranged from 36 to 96 ft^3/s. These decadal variations in ground-water discharge are driven by climate cycles. Comparing the ground-water discharge variations with precipitation at Crater Lake in the Cascade Range (both as cumulative departures from normal) shows that periods of high ground-water discharge generally correspond with periods of high precipitation (fig. 19).

Stream-gage data also provide information on temporal variations in ground-water discharge in the Metolius River drainage. As mentioned in the preceding section, the only long-term gage on the Metolius River is in the lower part of the drainage near Grandview, which measures discharge from a relatively large area. Because the drainage area represented by this gage includes runoff-dominated streams, the data cannot be used to evaluate seasonal variations in ground-water discharge. Evaluating the late summer and early fall flows, when most streamflow is ground-water discharge, however, can provide information on the long-term variations in ground-water discharge in the basin.

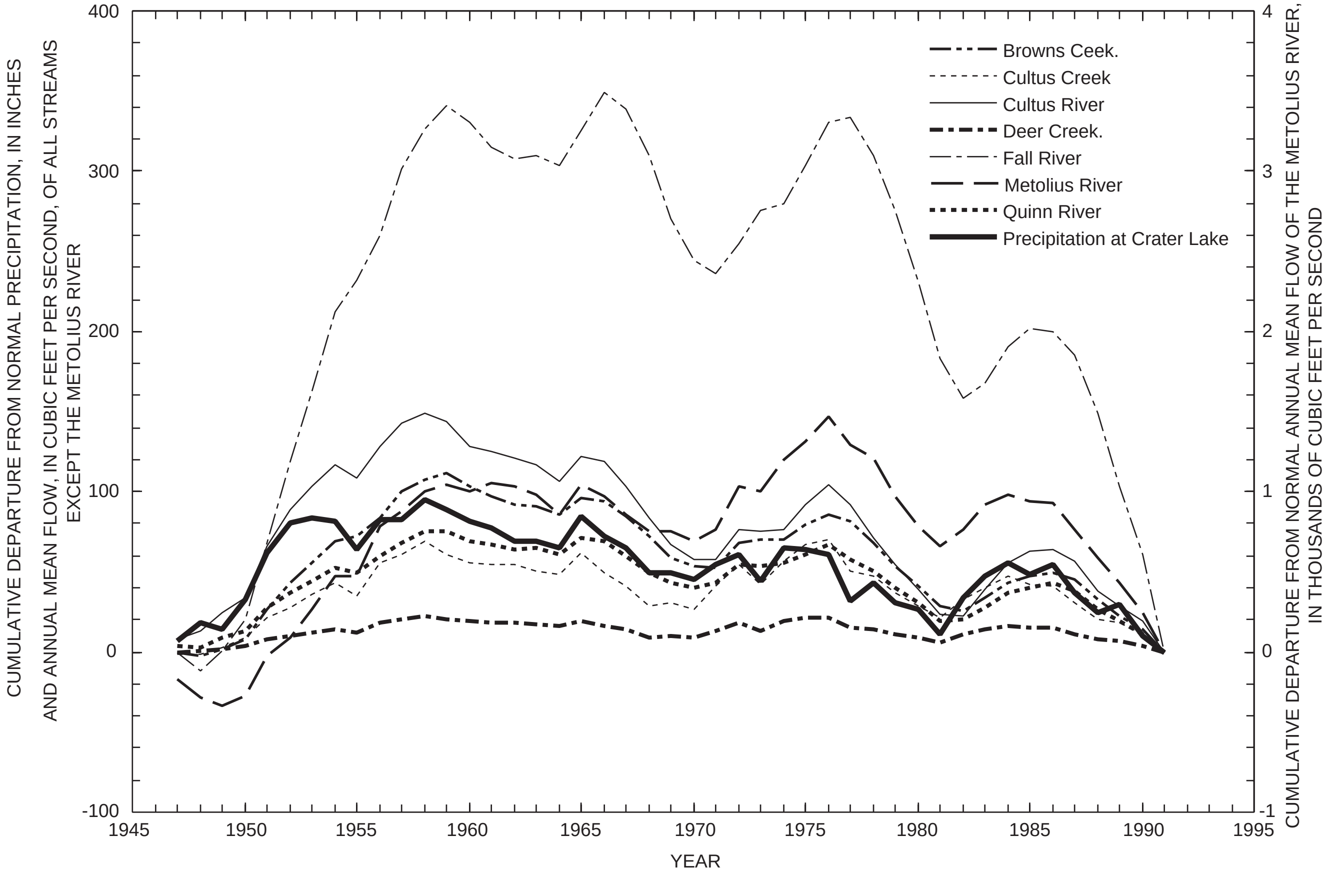

Figure 19. Cumulative departure from normal annual mean flows of selected streams in the upper Deschutes Basin, and cumulative departure from normal annual precipitation at Crater Lake, Oregon, 1947–91.

Before evaluating base flow to the Metolius River, the effects of tributary streams potentially carrying glacial meltwater during the late summer must be considered. In figure 20, a graph of October mean discharge values for the Metolius River is shown with similar graphs of Jefferson Creek and Whitewater River. Subtracting the flow of Jefferson Creek and Whitewater River shifts the graph of the Metolius River downward, but does not affect the overall shape of the graph or magnitude of variation (fig. 20). This suggests that the variations in October mean flows in the Metolius River are not greatly affected by these glacial streams and probably reflect variations in ground-water discharge.

Variations in long-term discharge of the Metolius River at Grandview exhibit a pattern similar to that seen in other Cascade Range streams. Comparison of the annual mean discharge of the Metolius River with precipitation at Crater Lake (both as cumulative departures from normal) shows that variations in base flow of the Metolius River follow variations in Cascade Range precipitation to a large degree, as is the case with other Cascade streams (fig. 19). Because of the size of the drainage basin, the magnitude of the decadal variation in ground-water discharge to the Metolius River is less than that in the smaller ground-water-dominated streams in the upper basin. For example, the 407 ft^3/s variation in October mean discharge of the Metolius River from 1962 to 1997 is about 30 percent of the mean October discharge for the period. The variation in October mean discharge for Fall River, by comparison, is about 74 percent of the mean October discharge flow for the same period.

Stream-gage data also allow evaluation of temporal variations in ground-water discharge in the area near the confluence of the Deschutes and Crooked Rivers. Data are available for reaches of both the Crooked and Deschutes Rivers above Lake Billy Chinook. In both cases, unmeasured tributary inflow during parts of the year preclude analysis of seasonal variations and allow analysis only of interannual and longer-term variations.

Variations in ground-water discharge to the Deschutes River in the confluence area can be evaluated by comparing discharge records from stream gages below Bend and near Culver just above Lake Billy Chinook. Seepage runs (table 5), discussed in a preceding section, indicate that most of the ground-water discharge to this reach occurs within 10 miles of Lake Billy Chinook.

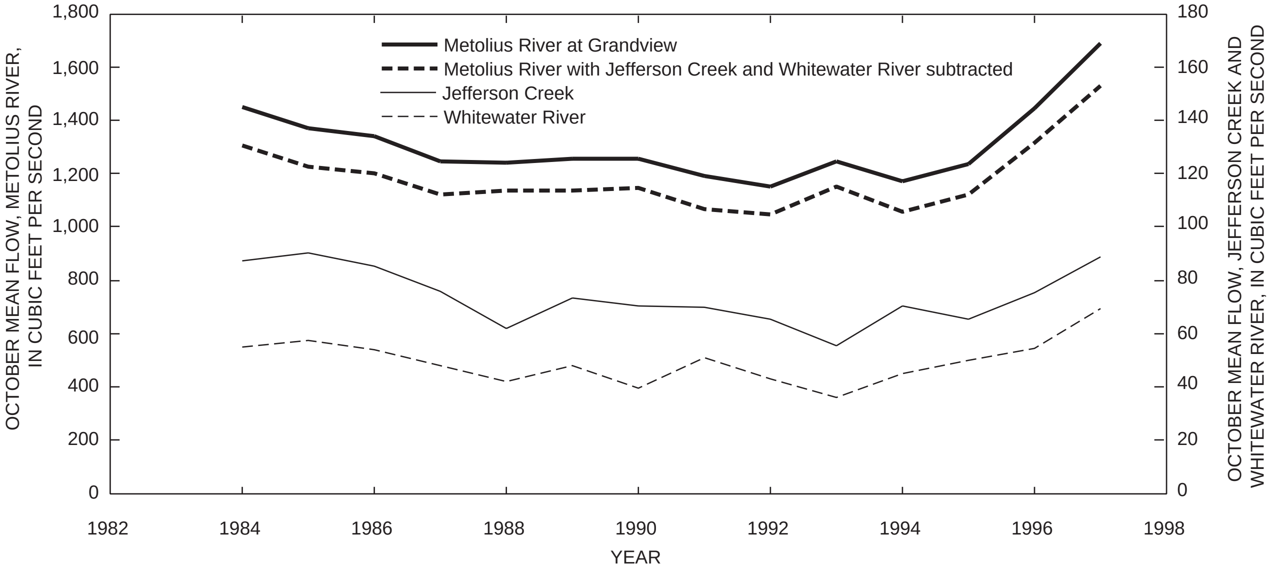

Figure 20. October mean flows of the Metolius River (near Grandview), Jefferson Creek, and Whitewater River, upper Deschutes Basin, Oregon, 1984–97.

Two major tributaries, Tumalo and Squaw Creeks, join the Deschutes River between the Bend and Culver gages. Neither of these tributaries have gaging stations near their mouths. During the irrigation season (April to November), most of the flow of these streams is diverted. Tumalo Creek flows only a few cubic feet per second at its confluence with the Deschutes River during this time (table 5). Squaw Creek typically flows about 100 ft^3/s at its confluence with the Deschutes River during the irrigation season (table 5), but nearly all of this flow is from springs (including Alder Springs) within 1.7 miles of the mouth. Flow in Squaw Creek above the springs is typically only a few cubic feet per second. It is reasonable, therefore, to consider the net gain in streamflow along the Deschutes River between the gages below Bend and near Culver during the late summer and early fall to be almost entirely due to ground-water discharge along the lower part of that reach, including the lower 2 miles of Squaw Creek.

A graph of the difference between August mean flows at the Bend and Culver gages from 1953 to 1997 (fig. 21) shows that August mean ground-water discharge varied from 420 to 522 ft^3/s and exhibited a pattern of variation similar to other streams in the basin. The 102 ft^3/s variation in August mean ground-water discharge to this reach of the Deschutes River from 1962 to 1997 is about 22 percent of the mean August value. This is less than the base flow variations of 30 and 76 percent for the Metolius and Fall Rivers, respectively, during this same period. The smaller variation in ground-water discharge to the Deschutes River results from the larger size of the ground-water contributing area and the distance from the source of recharge.

Variations in ground-water discharge to the lower Crooked River can be evaluated using the gage below Opal Springs. This gage is located in the midst of the most prominent ground-water discharge area in the Deschutes Basin. A seepage run made in June 1994 (table 5) showed that ground-water discharge between Terrebonne and the gage at Opal Springs (a distance of about 21 miles) exceeded 1,100 ft^3/s, of which over 1,000 ft^3/s entered the river in the lower 7 miles of this reach. During much of the year, the streamflow at the Opal Springs gage includes a large amount of surface runoff in addition to ground-water discharge (fig. 22). During the irrigation season, however, most of the flow above Terrebonne is diverted, and flow from up-stream into the ground-water discharge area is normally minuscule compared with the volume of ground-water inflow. Therefore, the late-summer flow at the Opal Springs gage is presumed to be almost entirely ground-water discharge except during anomalous storm events or reservoir releases.

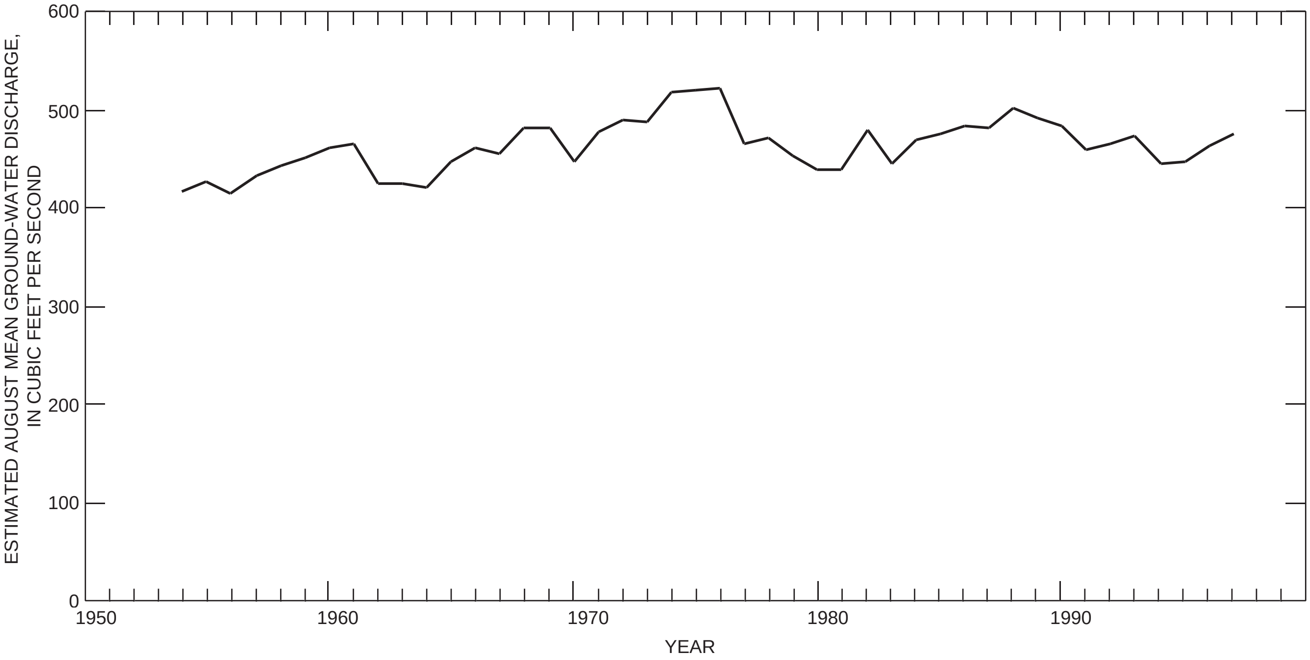

Figure 21. Approximate August mean ground-water discharge to the middle Deschutes River between Bend and Culver, based on the difference between August mean streamflows at gages below Bend and near Culver, 1954–97. (Fluctuations are caused by variations in ground-water discharge.)

August mean flows at the Opal Springs gage between 1962 and 1997 (fig. 22), representing ground-water discharge, exhibit climate-driven long-term variations apparent in other streams in the basin. August mean discharge for the period from 1962 to 1997 ranged from 1,133 to 1,593 ft^3/s, a variation of 460 ft^3/s, or 35 percent of the mean August discharge. The variation in July mean flows for the same period was only 28 percent. This variation is larger than one would expect given the volume of discharge, apparent size of the ground-water contributing area, and the observed variations in discharge to the Deschutes River.

This variation may be due to streamflow from above the ground-water discharge area. The Crooked River above the gage includes a very large area of runoff-dominated streams and two major reservoirs. The larger-than-expected variation may also be due to variations in canal leakage, which contributes ground-water inflow to the lower Crooked River.

Variations in ground-water discharge to the Metolius, Deschutes, and Crooked Rivers are driven by the same climatic trends and parallel each other. The variations, therefore, are additive and can combine to account for variations in late season monthly mean discharge on the order of 1,000 ft^3/s below the confluence area at the gage near Madras. Late-season (July to September) mean monthly flows at the gage near Madras, which are primarily ground-water discharge, average about 4,000 ft^3/s. Therefore, climate-driven variations in ground-water discharge can account for late-season streamflow variations of 25 percent at Madras.

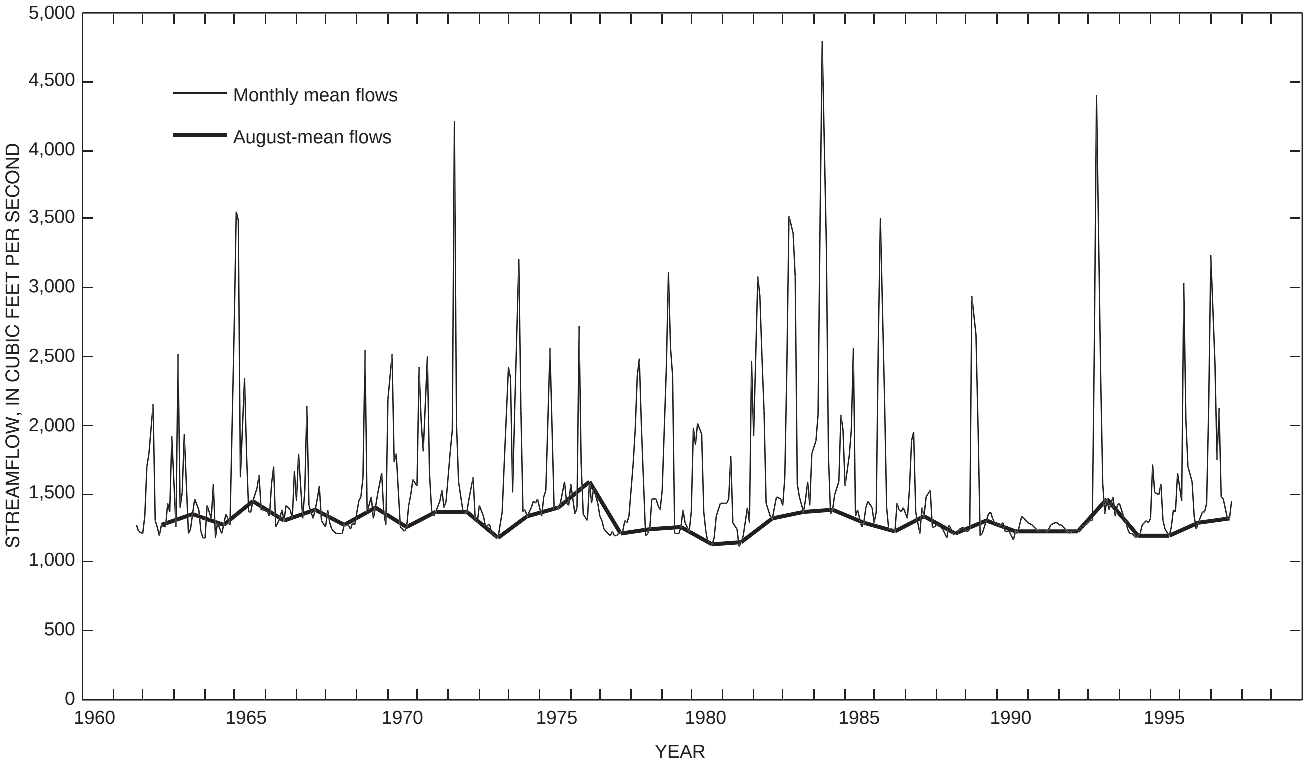

Figure 22. Monthly mean flows of the Crooked River at the gage below Opal Springs, 1962–97. (The line connecting August mean flows approximates late-season ground-water discharge.)

Analysis of stream-gage data from the lower Crooked River from the early 1900s through the 1960s shows an increase in ground-water discharge that is attributed to irrigation canal leakage. The graph of August mean discharge of the lower Crooked River (fig. 23) includes data from two different gage sites. Prior to the construction of Round Butte Dam and filling of Lake Billy Chinook, the gage was operated on the Crooked River at a now-inundated location near Culver, about 5.6 miles downstream from the present gage location. The flow is different at these two sites because the lower (former) site includes flow from springs not measured by the present gage, causing an offset between the two hydrographs. The hydrograph of August mean discharge of the lower Crooked River shows an overall increase of approximately 400 to 500 ft^3/s between 1918 and the early 1960s (fig. 23). The increase is given as a range because the exact amount is uncertain due to year-to-year variability in the flow. This steady, long-term trend of increasing discharge is not observed in other streams, such as the Metolius River, and does not appear to be caused by climate. It is also different from later long-term variations in August mean flows. This increase in base flow to the lower Crooked River is, however, similar in volume to estimated annual mean irrigation canal losses. Moreover, the growth of the increase is similar to that of estimated canal leakage (fig. 23). The return of water lost through canal leakage back to the surface as base flow to the Crooked River is consistent with ground-water flow directions in the area.

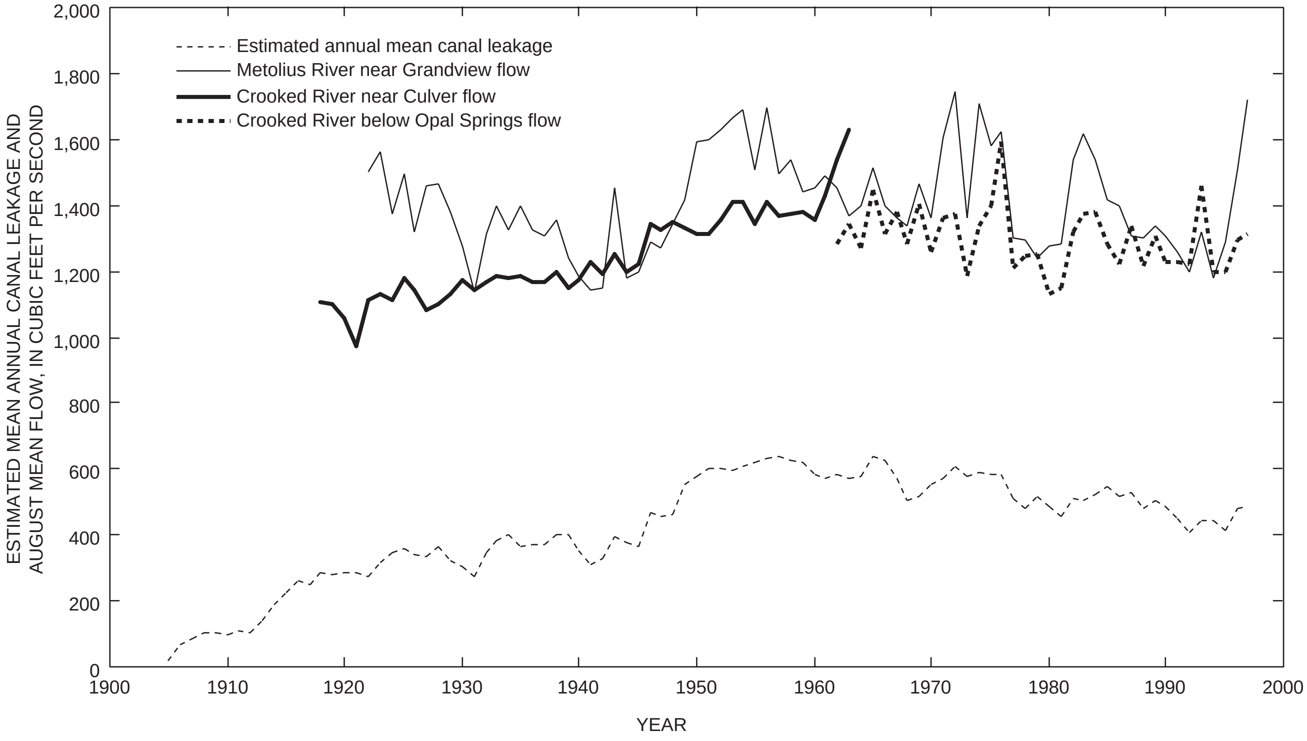

Figure 23. August mean flows of the Crooked River below Opal Springs, the Metolius River near Grandview, and estimated annual mean leakage from irrigation canals, 1905–97.

Ground-Water Discharge to Wells

Ground water is pumped from wells for a variety of uses in the upper Deschutes Basin, including irrigation, public supply, and private domestic use. Irrigation is primarily agricultural, but can include watering of golf courses and parks. Public-supply systems include publicly and privately owned water utilities, which are typically located in urban and suburban areas. Public-supply use includes not only drinking water, but also commercial, industrial, and municipal uses. Private domestic use generally refers to pumpage by individual wells that typically supply a single residence. Pumpage for each of these uses is discussed in this section.

Irrigation Wells

Pumpage of ground water for irrigation was estimated using water-rights information from the State of Oregon and crop-water-requirement estimates (fig. 24). Crop-water requirements were estimated, as previously described, for each irrigated 40-acre tract in the study area. The proportion of each tract irrigated with ground water was identified using water-rights information from the State of Oregon. A well serving as the primary source of water was identified for each tract irrigated using ground water. Where multiple wells supply water to the same 40-acre tract, the amount of water was proportioned between the wells based on the instantaneous rate information in the water-right files. For example, if it was determined that the crop-water requirements plus irrigation-efficiency requirements totaled 100 acre-ft/yr in a particular 40-acre tract, and that there were two wells with water rights listing instantaneous rates of 1 and 3 ft^3/s, then the two wells would be assigned annual pumpage rates of 25 and 75 acre-ft/yr respectively.

The crop-water requirements for all tracts, or parts thereof, were summed for each well. These sums were then divided by the irrigation efficiency (0.75) to derive an estimate of the total pumpage from each well. Water not lost through irrigation inefficiency or transpiration by plants is assumed to return to the ground-water system through deep percolation below the root zone and not be consumptively used.

Pumpage of ground water for irrigation was estimated to be about 14,800 acre-ft/yr (an average annual rate of 20.4 ft^3/s) during 1994, the year in which the crop-water requirements were estimated. Ground-water pumpage was estimated for each year from 1978 through 1997 by adjusting the 1994 pumpage up or down using an index reflecting the potential evapotranspiration and accounting for the change in the number of water rights with time. Potential evapotranspiration values were derived from the DPM (described in a previous section of this report) and adjusted to more accurately reflect rates measured by the BOR at the AgriMet site near Madras. Estimated ground-water pumpage for irrigation from 1978 to 1997 is shown in figure 24. The geographic distribution of average annual ground-water pumpage for irrigation from 1993 to 1995 is shown in figure 25.

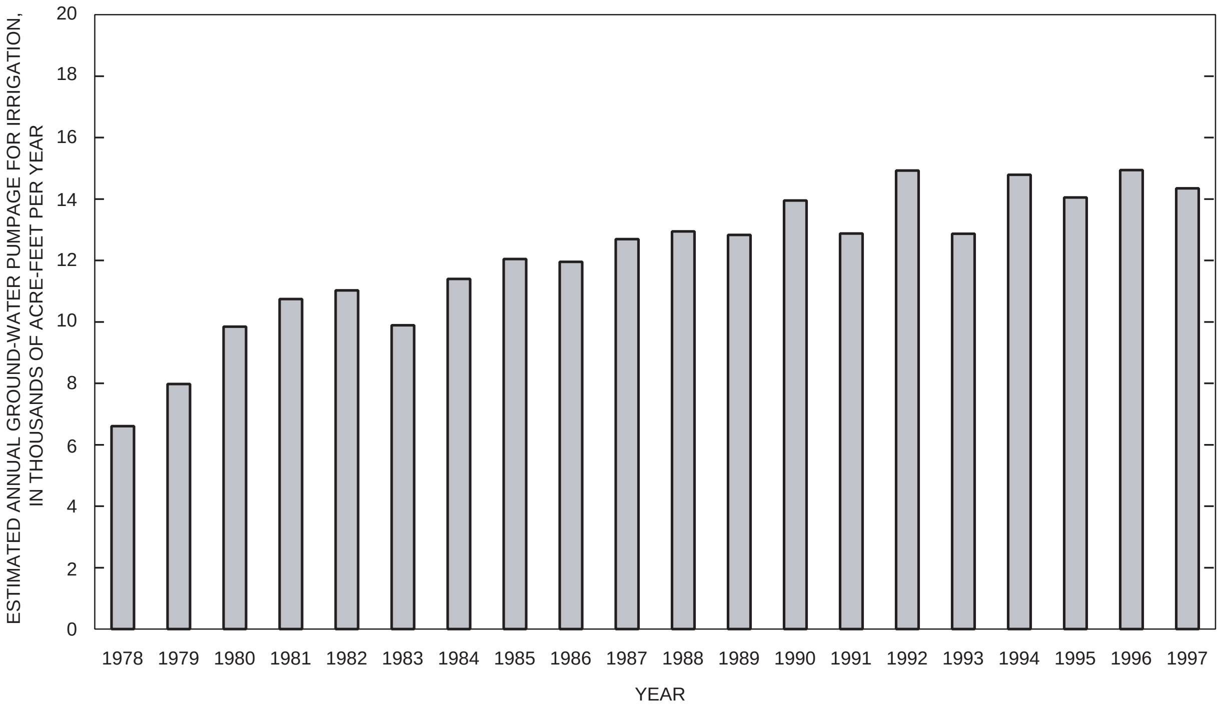

Figure 24. Estimated annual ground-water pumpage for irrigation in the upper Deschutes Basin, Oregon, 1978–97.

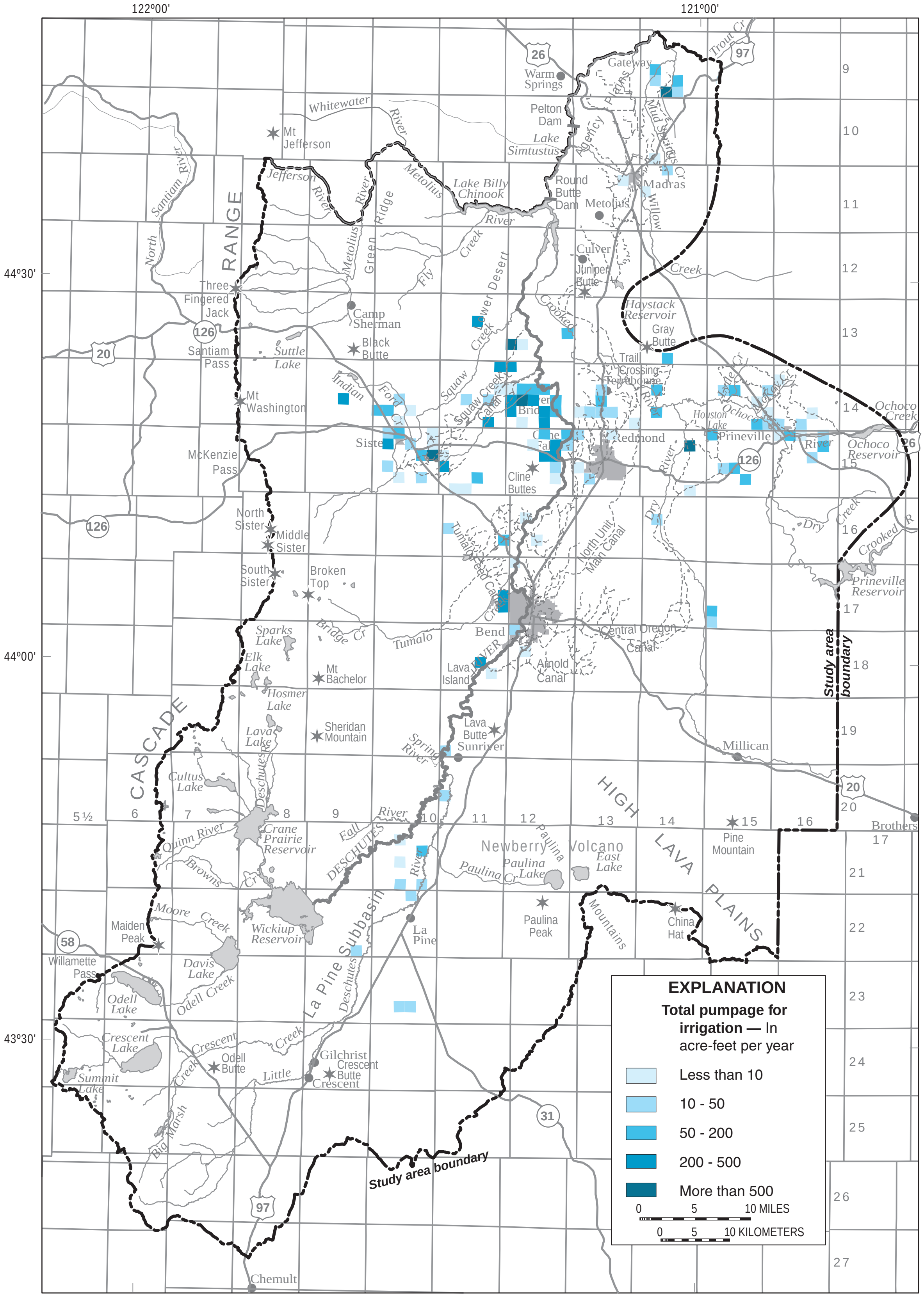

Figure 25. Estimated average annual ground-water pumpage for irrigation in the upper Deschutes Basin, Oregon, 1993–95, aggregated by section.

Public-Supply Wells

Public water-supply systems use a large pro-portion of the ground water pumped in the upper Deschutes Basin. Pumping for public water supplies has increased steadily in recent years in response to population growth (fig. 26). Total ground-water pumpage for public-supply use as of 1995 was estimated to be about 15,100 acre-ft/yr, an average rate of about 20.8 ft^3/s. Public-supply pumpage is concentrated primarily in urban and major resort areas, with scattered pumpage by smaller, rural systems (fig. 27).

Public-supply pumpage was estimated using data provided by operators of the 19 major municipal water systems and private water utilities in the upper basin. The quality and completeness of data from these systems varied widely. Some systems have totalizing flow meters on their wells, while others estimate pumpage using hour meters and known or calculated pumping rates. Complete records were not available for all systems for all years of interest. A variety of techniques was employed to estimate pumpage where records were incomplete or missing. Where data from early years were not available, pumpage was estimated by using estimates of the number of individuals served or the number of connections to the system. In cases where data were missing for certain time intervals, pumpage was estimated by interpolating between prior and later months or years. In some cases, total pumpage for a system was available, but pumping rates for individual wells within the system were only available for a few years or not at all. In such cases, the total pumpage each year was divided between the wells based on available data, and the proportions held constant from year to year.

Part of the ground water pumped for public supply returns to the ground-water system through a variety of processes, such as seepage from sewage infiltration ponds, leakage from transmission lines, infiltration from on-site septic systems (drainfields), and deep percolation during irrigation. The fraction of public-supply pumpage not returned to the ground-water system through these processes is considered to be consumptively used. The proportion of the gross public-supply pumpage that is consumptively used is not precisely known. Because most of the water returned to sewage treatment plants is returned to the ground-water system, subtracting the volume of water delivered to these plants from the gross amount pumped from wells can provide an estimate of the amount of ground water that is consumptively used.

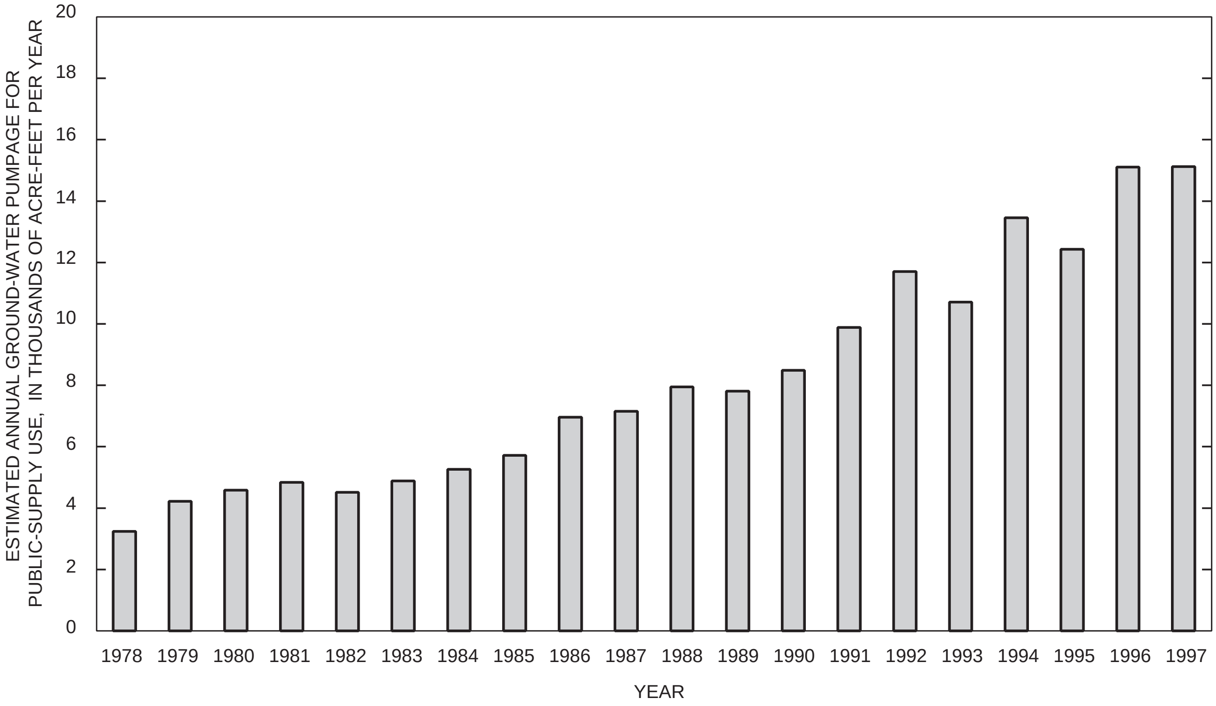

Figure 26. Estimated annual ground-water pumpage for public-supply use in the upper Deschutes Basin, Oregon, 1978–97. (Gross pumping figures do not represent actual consumptive use; a significant proportion of the pumped water returns to the ground-water system.)

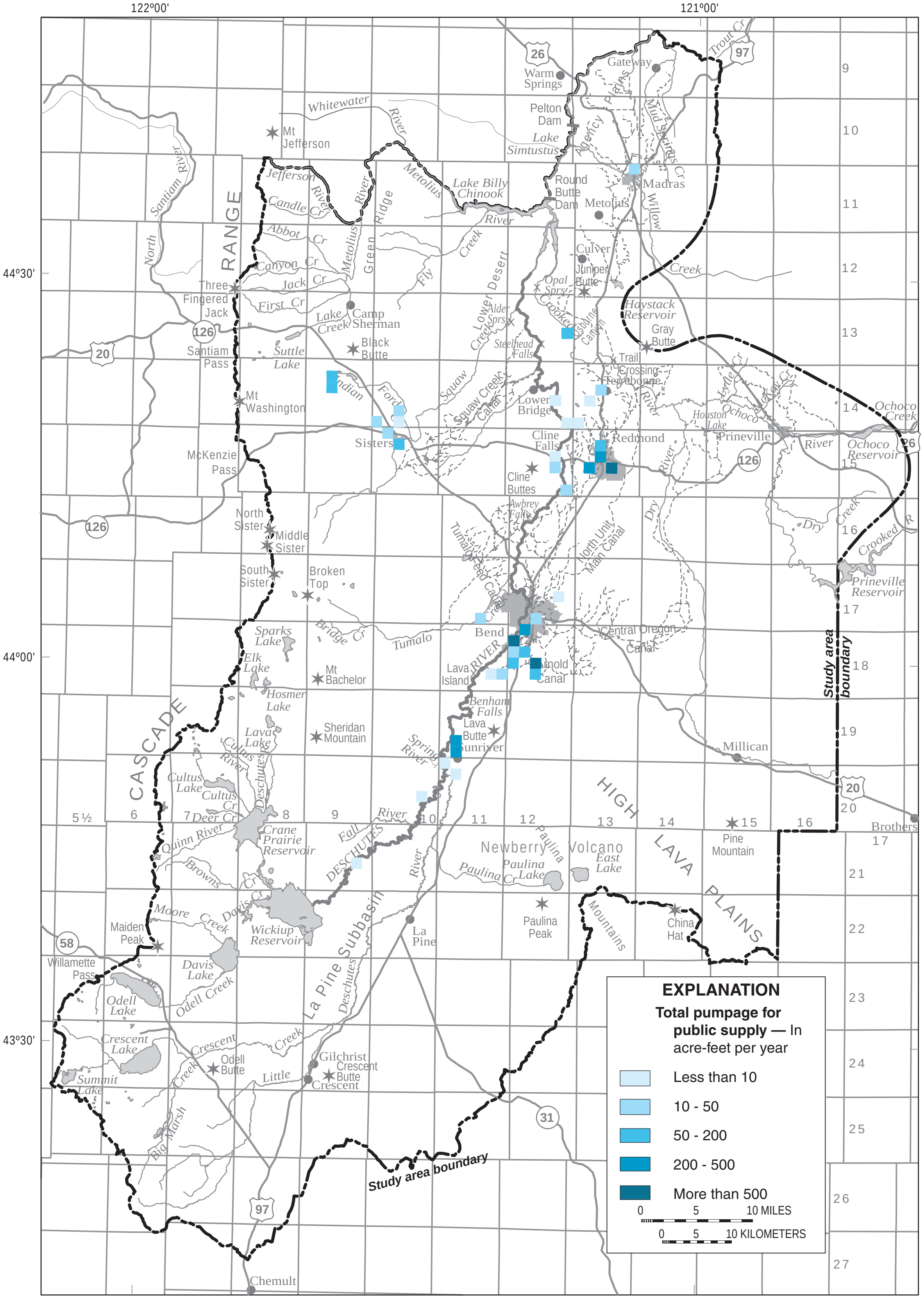

Figure 27. Estimated average annual ground-water pumpage for public-supply use in the upper Deschutes Basin, Oregon, 1993–95, aggregated by section. (Gross pumping figures do not represent actual consumptive use; a significant proportion of the pumped water returns to the ground-water system.)

Measurements of ground-water pumpage and wastewater flow for the cities of Redmond and Bend provide information on the percentage of ground-water pumpage consumptively used. Monthly measurements for Redmond from 1988 to 1997 show that, depending on the month, 22 to 92 percent of the ground water pumped is returned to the sewage treatment plant as wastewater (Pat Dorning, City of Redmond, written commun., 1999). Return flows for the city of Bend are comparable to those of Redmond (Roger Prowell, City of Bend, oral commun., 1999). During winter, when water use is relatively low, 80 to 90 percent of the ground water pumped is returned as wastewater, and only 10 to 20 percent is unaccounted for. During summer, when water production is about four times the winter rate, only about 20 to 40 percent of the ground water pumped is returned as waste-water, leaving 60 to 80 percent unaccounted for. The water not returned as wastewater is not, however, all consumptively used. Part of the water not returned as wastewater returns to the ground-water system through leakage from supply and sewer lines. This type of leakage may account for as much as 8 percent of the total pumpage (Jan Wick, Avion Water Company, oral commun., 1999). A large amount of the increased water production during the summer is used for irrigation of lawns, gardens, and parks. Much of this water is used consumptively, lost through evaporation and transpiration by plants, but some percolates below the root zone and returns to the ground-water system. Because municipalities and urban home owners generally employ relatively efficient irrigation techniques such as sprinklers, as opposed to inefficient techniques such as flood irrigation, it is probably reasonable to assume that a large proportion of the increased summer production is used consumptively, but the exact amount in unknown.

Additional sources of error may be present in consumptive-use estimates based on wastewater return flow. In urban areas, some of the wastewater returned to sewage treatment plants is lost through evaporation from sewage lagoons or infiltration ponds. If sewage effluent is used to irrigate fields, a considerable amount may be lost through evapotranspiration. Consumptive-use estimates may be low if it is assumed that all the wastewater returned to sewage treatment plants is returned to the ground-water system.

Estimates of the proportion of ground-water pumpage that is actually consumed and not returned to the ground-water system are clearly influenced by many sources of error and must be considered approximate. Available data suggests that consumptive use ranges from approximately 10 percent of the total pumpage during winter, to approximately 50 to 70 percent during the high-water-use summer. On an annual basis, about 43 percent of the ground water pumped by the city of Redmond, for example, is returned as wastewater, leaving 57 percent of the water unaccounted for. Return-flow figures and transmission-loss estimates suggest that consumptive use of ground water in urban areas is probably some-what less that 50 percent of the gross annual pumpage.

Private Domestic Wells

Not all residents of the upper Deschutes Basin are connected to public water supplies; many rely on private domestic wells. Private domestic well use was estimated using OWRD water-well-report files, data from the Oregon Health Division, Drinking Water Section (Dennis Nelson, written commun., 1999), population data from the State of Oregon (1999), and 1990 census data (U.S. Department of Commerce, 1993). As of 1995, an estimated 34,000 individuals, about 27 percent of the population of the study area, obtained water from private domestic wells or small water systems. The percentage of residents on private wells varies between counties. As of 1995, about 22,000 people, or 24 percent of the population, obtained water from private wells in Deschutes County. In Jefferson County, about 1,900 people, 12 percent of the population, relied on private wells. In Crook County, about 8,000 people, 52 percent of the population, obtained water from private wells. An estimated 1,900 people relied on private wells in Klamath County in the study area.

The amount of ground-water pumpage by private domestic wells can be roughly estimated based on number of individuals served by such wells. Per capita water use in the upper Deschutes Basin, estimated by using data from public water-supply systems, varies considerably between systems. Records from public water suppliers indicate that average daily per capita water use for the largest public-supply systems in the study area ranges from 100 to 300 gal/d. Some of these systems supply commercial and municipal uses, and the per capita figures from them are not representative of rural dwellings. Many of the private wells in the study area are in rural residential areas served by irrigation districts, so well water is not used for irrigation of lawns and gardens. Because water from private domestic wells is used primarily for indoor use and not irrigation, per capita pumpage from rural residential domestic wells is considered for estimation purposes to be at the lower end of the calculated range, 100 gal/d.

If an average per capita pumpage of 100 gal/d is used, ground-water pumpage by private domestic wells (assuming 34,000 individuals are served) is approximately 3.4 million gal/d, which equals an average annual rate of 5.3 ft^3/s. As is discussed in the previous section, all of this water is not used consumptively. Virtually all of the homes on private domestic wells also use on-site septic systems, so most of the water pumped is returned to the ground-water system through drainfields. Actual consumptive use of ground water by private domestic wells in the upper Deschutes Basin is, therefore, likely less than 1 to 2 ft^3/s.

Ground-Water Discharge to Evapotranspiration

Most consumption of water by evapotranspiration occurs in the unsaturated zone. This water is intercepted as it percolates downward through the unsaturated zone prior to becoming ground water. Evapotranspiration from the unsaturated zone is accounted for by the DPM and occurs outside of the ground-water budget. Thus, the evapotranspiration of water from the unsaturated zone is not considered ground-water discharge. There are, however, circumstances in which evapotranspiration does consume ground water from the saturated zone. This occurs when the water table is sufficiently shallow to be within the rooting depth of plants, on the order of 5 to 10 ft deep. Evapotranspiration of water in this manner is considered ground-water discharge.

Broad areas with shallow ground-water conditions as described above are rare in the upper Deschutes Basin. The La Pine subbasin is the only significant large region in the study area with shallow ground-water conditions necessary for evapotranspiration from the water table. Areas of shallow ground water occur in the drainages of the upper Metolius River and Indian Ford Creek as well, but these are small in comparison to the La Pine subbasin. The potential amount of evapotranspiration from the water table in the La Pine subbasin was estimated to evaluate the significance of this process to the overall ground-water budget.

The DPM described earlier in this report calculated the amount of potential evapotranspiration throughout the study area. It also calculated the proportion of the potential evapotranspiration satisfied by evapotranspiration from the unsaturated zone. The proportion of the potential evapotranspiration not satisfied in this manner is the remaining amount that could be satisfied by evapotranspiration from the water table, and is termed the residual evapotranspiration. The DPM estimated that the residual evapotranspiration in the La Pine area equals an average annual instantaneous rate of about 5.7×10^{-8} ft/s (feet per second) (22 in/yr), which is equivalent to about 1.6 ft^3/s/mi2. The probable area over which the water table is within 10 ft of land surface in the La Pine subbasin is estimated to be about 50 mi2, based on water-level measurements in the La Pine subbasin taken in June 1999. During that time of year, the rate of evapotranspiration would be greatest. If the maximum residual evapotranspiration is lost to evapotranspiration over the entire 50 mi^2, it would represent an average annual rate of about 80 ft^3/s. To transpire at the full residual evapotranspiration rate, however, the water table would have to be virtually at land surface. In reality, the water table is probably near the margin of the rooting depth of plants, so the actual amount of evapotranspirative loss from the water table is probably much less than 80 ft^3/s. The values for evapotranspiration presented in this section are rough estimates, but serve to illustrate the magnitude of the probable ground-water discharge through evapotranspiration for comparison with other parts of the ground-water flow budget.

Ground-Water Elevations and Flow Directions

Hydrologists describe the force driving ground-water movement as *hydraulic head*, or simply, head. Ground water flows from areas of high head to areas of low head. In an unconfined aquifer, such as a gravel deposit along a stream or a fractured lava flow near land surface, the elevation of the water table represents the head at the upper surface of the aquifer. Ground water flows in the direction the water table slopes, from high-elevation (high-head) areas toward low-elevation (low-head) areas. The change in head with distance, or *head gradient*, is simply the slope of the water table. Some aquifers, however, are confined by overlying strata with low permeability called *confining units*. A confined aquifer, for example, may be several hundreds of feet below land surface. The water in such an aquifer is often under pressure. When a well penetrates the aquifer, the water will rise in the well to some elevation above the top of the aquifer. The elevation to which the water rises is the head at that place in the aquifer. Water moves in confined aquifers from areas of high head to areas of low head just as in unconfined aquifers. Multiple confined aquifers can occur one on top of another separated by confining units. The heads in multiple confined aquifers may differ with depth resulting in vertical head gradients. If a well connects multiple aquifers with different heads, water can flow up or down the well from the aquifer with high head to the aquifer with low head. The distribution of head in an unconfined aquifer is represented by the elevation and slope of the water table. The distribution of head in a confined aquifer is represented by an imaginary surface known as a *potentiometric surface*. A potentiometric surface can be delineated by evaluating the static water-level elevations in wells that penetrate a confined aquifer.

In this report, the distinction between confined and unconfined aquifers is not critical to most of the discussion and is generally not made. The term *ground-water elevation* is used instead of head in the following discussion because it is more intuitively understandable. Furthermore, the term *water table* is used loosely to describe the general distribution of ground-water elevation in an area whether the aquifers are confined or unconfined. The important concept is that ground water moves from areas of high ground-water elevation (high head) to areas of low ground-water elevation (low head). In the upper Deschutes Basin, ground-water elevations are highest in the Cascade Range, the locus of ground-water recharge in the basin, and lowest in the vicinity of the confluence of the Deschutes, Crooked, and Metolius Rivers, the principal discharge area.

The geographic distribution of ground-water elevations in the upper Deschutes Basin was determined in this study using a variety of types of data. In the developed parts of the study area, primarily the areas of privately owned land, water-level elevations were determined by measuring water levels in wells. In some instances, conditions precluded measurements and water levels reported by drillers were used. Data from geothermal exploration wells provided a small amount of water-level information in the Cascade Range and at Newberry Volcano. Very few water wells exist in the vast tracts of public land that compose much of the upper Deschutes Basin. In those areas, the sparse water-well data was augmented with elevation data from large volume springs and gaining stream reaches. Major discharge features such as these represent points at which the water-table elevation and land-surface elevation coincide.

Horizontal Ground-Water Flow

In the upper Deschutes Basin, ground water moves along a variety of paths from the high-elevation recharge areas in the Cascade Range toward the low-elevation discharge areas near the margins of the Cascade Range and near the confluence of the Deschutes, Crooked, and Metolius Rivers. The generalized ground-water elevation map (fig. 28), based on hydraulic-head measurements in deep wells and on the mapped elevations of major springs and gaining stream reaches, shows the general direction of regional ground-water flow in different parts of the upper basin. The map is generalized and does not reflect local areas of shallow ground water caused by irrigation and canal and stream leakage.

In the southern part of the upper Deschutes Basin, ground water flows from the Cascade Range (including the Mt. Bachelor area) towards the high lakes area and the Deschutes and Little Deschutes Rivers in the La Pine subbasin. Ground water flows from Newberry Volcano toward the La Pine subbasin and toward the north. The water table in the La Pine subbasin is relatively flat, with an elevation of about 4,200 ft and a slight gradient generally toward the north-northeast. In this area the water table is shallow, often within several feet of land surface. North of Benham Falls, the gradient increases dramatically and the water table slopes steeply to the northeast. As a result, the regional water table, which is very close to land surface in the La Pine subbasin, is several hundred feet below land surface near Bend.

Ground-water elevations are relatively high in the southeast part of the Deschutes Basin near Millican, indicating that ground water flows from that area toward the northwest into the lower parts of the basin. As described previously, some water likely enters the southeastern part of the Deschutes Basin from the Fort Rock Basin (Miller, 1986). In the northern part of the study area, ground water flows from the Cascade Range to the northeast into the lower part of the basin toward ground-water discharge areas near the confluence of the Deschutes, Crooked, and Metolius Rivers.

In the central part of the study area, around Bend, Redmond, and Sisters, the water table is relatively flat between an elevation of 2,600 and 2,800 ft, although there is a gradual gradient to the north toward the confluence area (fig. 28). The water table in the Bend area is generally hundreds of feet below land surface. The northward slope of the water table is less than the northward slope of the land, however, so the water table is closer to land surface in the Redmond area. North of Redmond, the deep canyons of the Deschutes and Crooked Rivers are incised to the elevation of the regional water table, so ground water flows toward, and discharges to, streams that act as drains to the ground-water flow system. Water-level contours are generally parallel to the canyons in the confluence area, indicating flow directly toward the rivers.

A striking feature of the generalized water-table map (fig. 28) is the linear zone of closely spaced contours (indicating a high horizontal head gradient) that trends northwest-southeast across the upper basin. There are at least four possible explanations for this feature. First, the feature generally follows the topography. It also is likely related to the distribution of precipitation, which shows a similarly oriented high gradient region, particularly in the northern part of the mapped area. The flattening of the water-table surface to the northeast, which partly defines the high-gradient zone, is likely due to permeability contrasts related to the stratigraphy. The low-gradient area in the northeastern part of the map corresponds to that part of the Deschutes Formation where permeable fluvial deposits are an important component. Lastly, the linear zone could be, in part, an artifact of the geographic and vertical distribution of head data, particularly southeast of Bend where data are sparse. The northwest-trending high-head-gradient zone does not generally correspond with mapped faults.

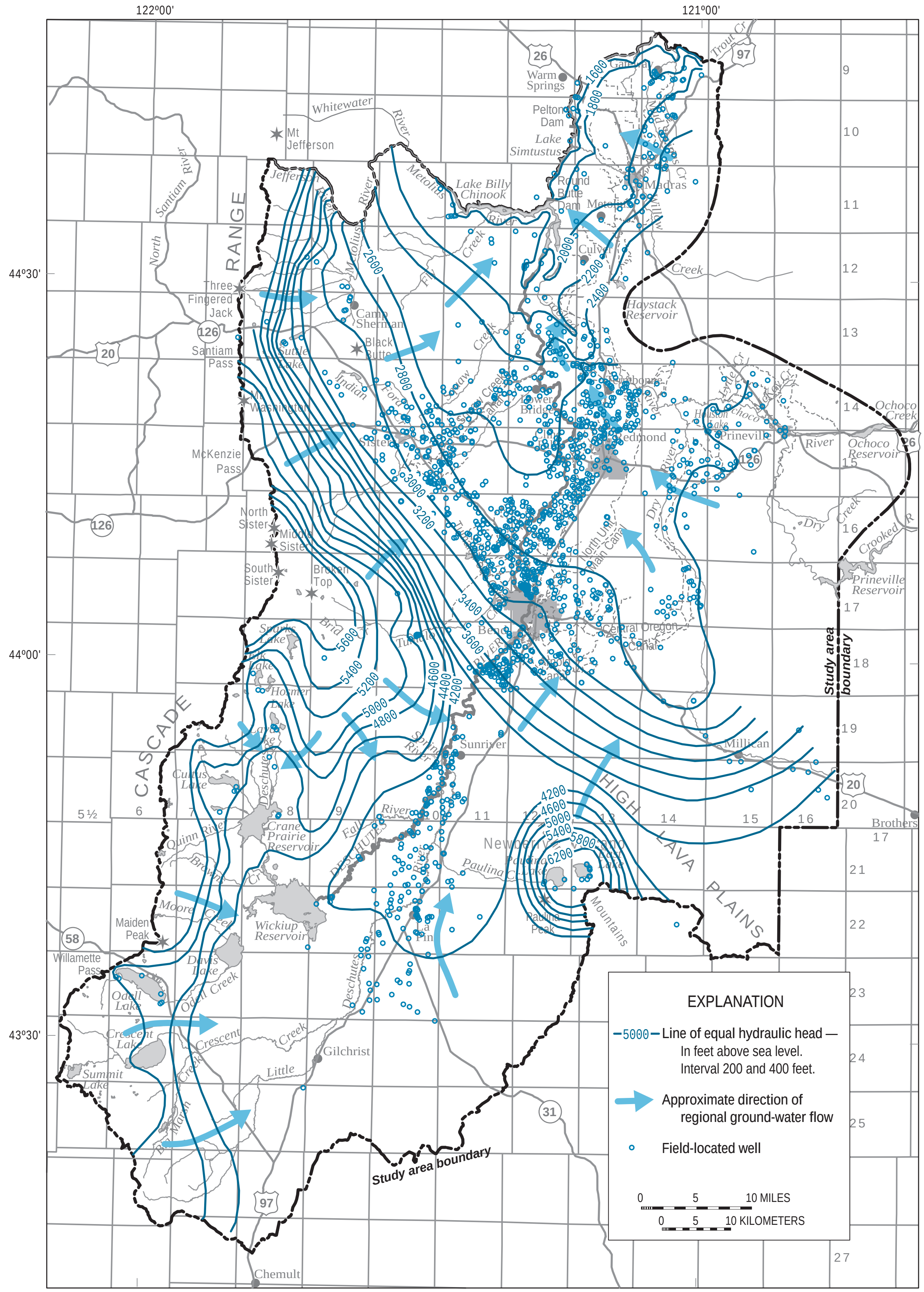

Figure 28. Generalized lines of equal hydraulic head and ground-water flow directions in the upper Deschutes Basin, Oregon. (This map does not reflect shallow, local saturated zones caused by canal and stream leakage. Arrows show approximate direction of regional ground-water flow.)

Vertical Ground-Water Flow

Ground-water elevation (or head) can vary vertically as well as horizontally. At many locations, wells with different depths have different water levels. In recharge areas, where water enters the ground-water system, ground water generally moves downward and there is a downward head gradient (fig. 29). In recharge areas, water-level elevations are lower in deep wells and higher in shallow wells. If a well penetrates multiple aquifers in a recharge area, water can flow downward in the well from one aquifer to another. In areas where ground-water flow is primarily horizontal and there is little vertical movement of water, vertical gradients are small. In discharge areas, water from deep aquifers under pressure moves upward from depth and there is an upward head gradient. In discharge areas, deep wells have higher water-level elevations than shallow wells, and, if upward head gradients are sufficiently large, water levels in deep wells can be above land surface, causing water from the wells to flow at land surface.

Downward head gradients are common throughout much of the upper Deschutes Basin, including the Cascade Range and lower parts of the basin around Bend and Redmond. In the Cascade Range, the large amount of recharge causes downward movement of ground water and strong downward head gradients. Evidence of this downward flow in the Cascade Range is commonly seen in temperature-depth logs of geothermal wells (Blackwell, 1992; Ingebritsen and others, 1992). Temperature data show downward flow to a depth of at least 1,640 ft below land surface in an exploration well drilled near Santiam Pass (Blackwell, 1992). Similar large downward head gradients were observed in the Mt. Hood area in the Cascade Range north of the study area by Robison and others (1981).

Downward head gradients in the lower parts of the basin result primarily from artificial recharge from leaking irrigation canals. Ground-water elevations are artificially high in areas around networks of leaking irrigation canals. In some places, artificially high ground-water levels are observed only in scattered wells close to major canals. In other places, such as north and northwest of Bend, high ground-water elevations are maintained over a broad region by canal leakage. There are also isolated areas of shallow ground water that may be related to natural recharge from stream leakage.

Separate sets of water-level elevation contours for shallow wells (generally 100 to 300 ft deep) and deep wells (generally 500 to 900 ft deep) were drafted for the area around Bend, Redmond, and Sisters (fig. 30). In the area north and northwest of Bend, water-level elevations in shallow wells are 200 to 400 ft higher than water-level elevations in deep wells. At some locations, water levels in shallow and deep wells differ by over 500 ft. The shape and location of this area of high water levels suggests that it is caused by canal losses; for the most part it does not coincide with potential natural sources of recharge. Caldwell (1998) showed that shallow ground water is isotopically very similar to canal and stream water, which also suggests that canal and stream leakage are a principal source of recharge for shallow ground water.

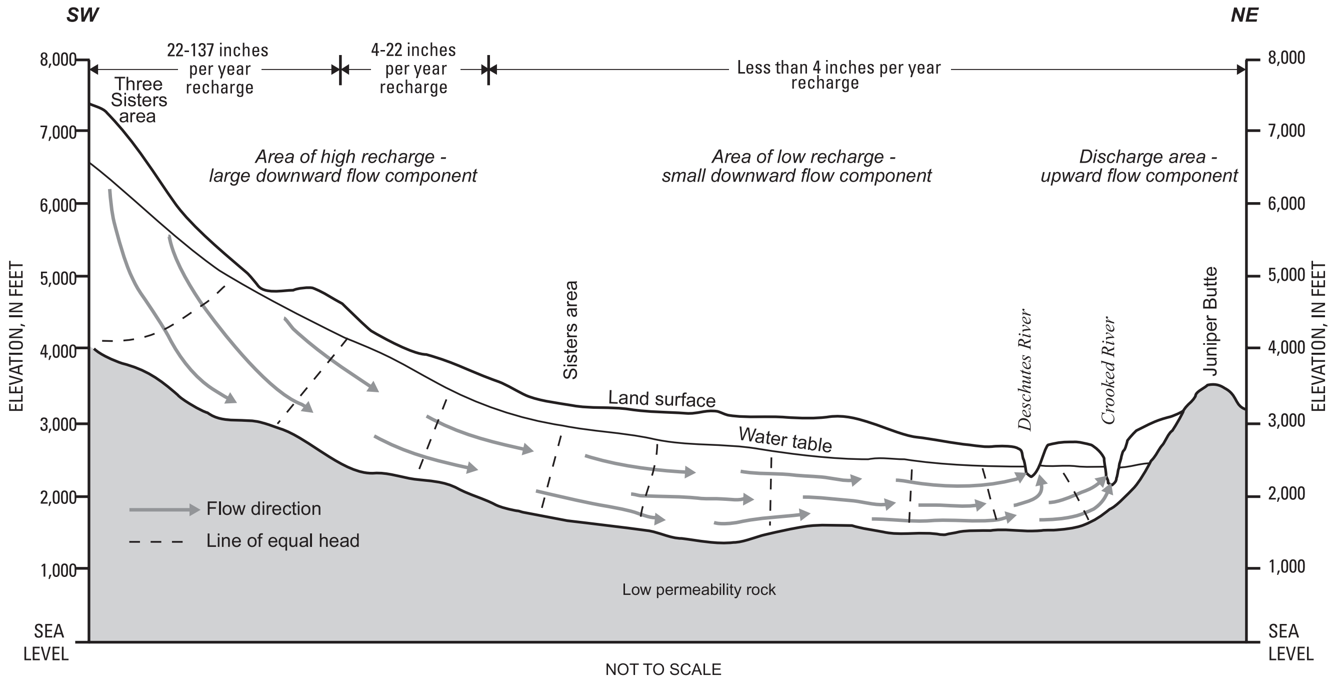

Figure 29. Diagrammatic section southwest-northeast across the upper Deschutes Basin, Oregon, showing flow directions and lines of equal hydraulic head.

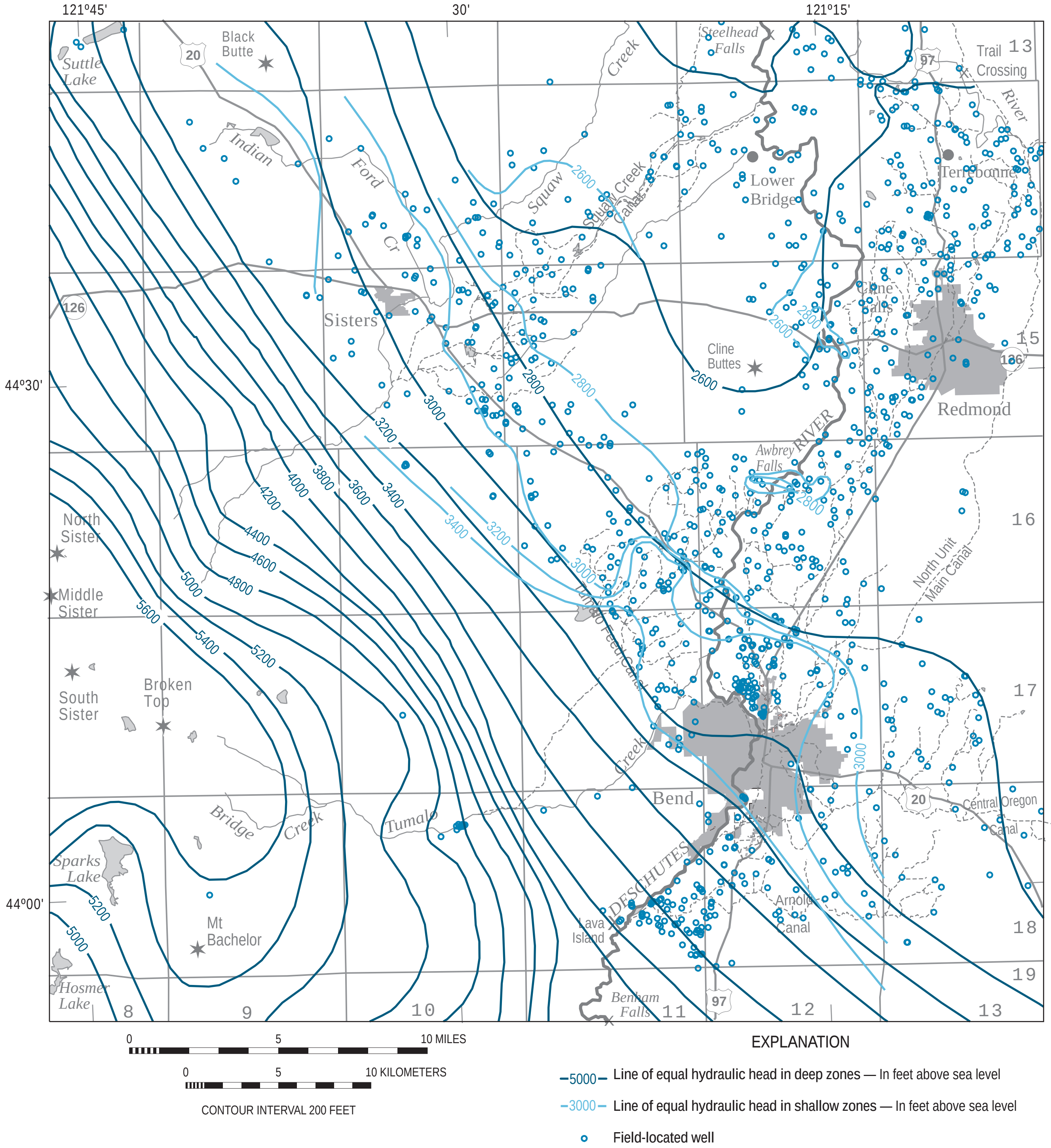

Figure 30. Generalized lines of equal hydraulic head for shallow and deep water-bearing zones in the central part of the upper Deschutes Basin, Oregon. (Elevated heads in shallow zones are due to infiltration of water from leaking irrigation canals, on-farm losses, and stream leakage.)

There are isolated areas in the upper Deschutes Basin where anomalously high ground-water elevations likely result from natural causes. Such areas are present along the Deschutes River about halfway between Bend and Redmond (near Awbrey Falls) and west of Redmond. Elevated shallow water levels in these areas are likely caused by natural leakage from the Deschutes River. The relatively high shallow ground water in the Sisters area is also probably natural, as no significant source of artificial recharge is present.

Local recharge from leaking irrigation canals throughout the populated areas in the lower basin, and the resulting vertical head gradients, cause water-level elevations to vary from well to well in an area depending on the depth. In addition, water-level elevations can vary as the canals are turned on and off. Consequently, it can be difficult to accurately predict the depth to water at many locations, particularly where data from wells are sparse.

Upward head gradients are not commonly encountered in the upper Deschutes Basin. There are a number of possible causes for this. There is widespread artificial recharge from canal leakage and deep percolation of irrigation water throughout much of the populated area resulting in widespread downward gradients over most of the area where there are data. In addition, the streams to which most ground water discharges in the lower basin have cut deep into the aquifer system, allowing much of the water to discharge laterally without upward vertical movement. Finally, there are few wells that penetrate to depths below the elevation of streams in the major discharge area, where upward gradients would be expected.

A substantial upward head gradient exists in the area of the lower Crooked River at depths below river level. A 740-ft well drilled near river level at Opal Springs had an artesian flow of 4,500 gal/min and a shut-in pressure of 50 pounds per square inch, indicating that the aquifer tapped by the well has a hydraulic head (water-level elevation) over 115 ft above the elevation of the river. This large upward gradient indicates upward ground-water flow toward the river.

Fluctuations in Ground-Water Levels

The elevation of the water table is not static; it fluctuates with time in response to a number of factors, the most important of which are variations in recharge, canal operation, and pumping. In this section, ground-water-level fluctuations in the upper Deschutes Basin are described, the controlling factors identified, and the implications with regard to the regional hydrology are discussed.

Ground-water-level fluctuation data are collected by taking multiple water-level measurements in the same well over a period of time. Multiple water-level measurements are available for 103 wells in the upper Deschutes Basin. These wells were monitored for periods ranging from less than 1 year to more than 50 years; measurements were taken at intervals ranging from once every 2 hours (using automated recording devices) to once or twice a year. Fourteen wells in the basin have been monitored by OWRD for periods ranging from 9 to more than 50 years. Generally, measurements have been taken in these wells one to four times a year. Seventy-three wells were measured quarterly during this study for periods ranging from1 to 4 years. Nineteen of these wells also were measured quarterly for 1 to 2 years during the late 1970s. Sixteen wells were instrumented with continuous recorders, devices that measured and recorded the water-level elevation every 2 hours. These short-interval measurements effectively create a continuous record of water-level elevation changes. Graphs of water-level fluctuations in all of these wells are published in the data report for this study (Caldwell and Truini, 1997).

Large-Scale Water-Table Fluctuations

The most substantial ground-water-level fluctuations in the upper Deschutes Basin, in terms of both magnitude and geographic extent, occur in and adjacent to the Cascade Range, including parts of the La Pine subbasin. These fluctuations are exemplified by the hydrographs of wells 21S/11E-19CCC, near La Pine, and 15S/10E-08ACD, near Sisters (fig. 31). The water level in both these wells fluctuates up to 20 ft with a cycle averaging roughly 11 years. A comparison of these water-level fluctuations with precipitation at Crater Lake in the Cascade Range (fig. 31) indicates that periods of high ground-water-level elevations generally correspond to periods of high precipitation, and low water-level elevations correspond to periods of low precipitation. This relation, of course, is to be expected. During periods of high precipitation, the rate of ground-water recharge exceeds, at least temporarily, the rate of discharge. When ground-water recharge exceeds discharge, the amount of ground water in storage must increase, causing the water table to rise. During dry periods, in contrast, the rate of discharge may exceed the rate of recharge, and ground-water levels drop as a result.

Fluctuations in the water-table elevation in response to variations in recharge are most prominent in the Cascade Range, the primary recharge area. A comparison of hydrographs of wells at varying distances from the Cascade Range (fig. 32) shows that as distance from the recharge area increases, the magnitude of fluctuations decreases, and the timing of the response is delayed.

During the period from 1993 through early 1999, ground-water levels in and near the Cascade Range, such as in wells 14S/9E-08ABA and 15S/10E-08ACD, rose over 20 ft in response to an abrupt change from drought conditions to wetter-than-normal conditions. Wells 15S/10E-36AAD2 and 15S/10E-02CDA, a few miles to the east of Sisters, farther

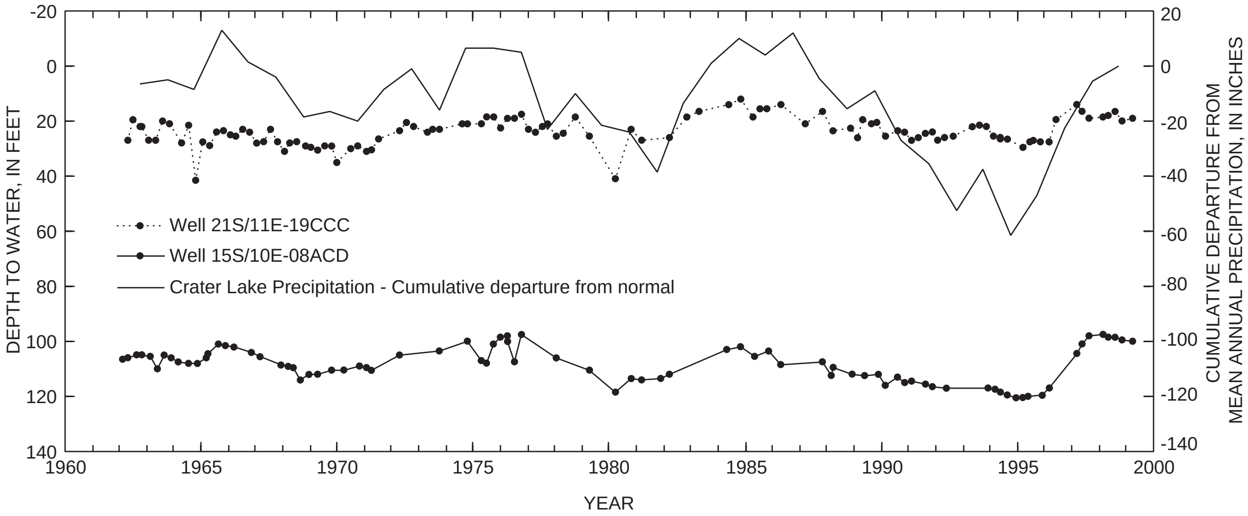

Figure 31. Static water levels in two long-term observation wells in the upper Deschutes Basin, Oregon, and cumulative departure from normal annual precipitation at Crater Lake, Oregon, 1962–98.

away from the Cascade Range, showed a smaller rise in water level (less than 20 ft), and a slight delay in response. Well 14S/12E-09ACB several miles farther east near Lower Bridge, exhibited only a slight rise in water level, less than 2 ft, in response to the end of the drought, and an apparent delay in response. Long-term trends in wells with seasonal fluctuations, such as well 14S/12E-09ACB, are evaluated by comparing annual high and low water levels from year to year. Farther east near Redmond, water levels in wells 15S/13E-04CAB and 15S/13E-18ADD had barely stopped declining even 2 years after the end of the drought. Water levels in these wells had not started to rise as of early 1999.

Long-term records show that the water level in well 15S/13E-18ADD has fluctuated about 10 ft since 1971 compared to 23 ft in well 15S/10E-08ACD to the west closer to the recharge area (Caldwell and Truini, 1997, fig. 8). In addition, the decadal-scale peaks and troughs in the hydrograph of well 15S/13E-18ADD are broad and lag those of the well 15S/10E-08ACD by roughly 2 years.

The eastward-increasing delay in the water-level response to changes in recharge in the Cascade Range is depicted by a series of maps in figure 33. These maps show the annual direction of water-level change from March 1994 to March 1998 for observation wells throughout the upper basin. From March 1994 to March 1995, during the drought, water levels dropped in nearly all wells. Between March 1995 and March 1996, water levels in wells along the Cascade Range margin rose while water levels in wells to the east continued to decline. Over the next 2 years, the trend of rising water levels migrated eastward.

The attenuation and delay of water-level fluctuations with distance from the recharge source is analogous to the attenuation and delay in ground-water discharge peaks with increasing basin size, as discussed in the previous section. The effects of recharge variations are diffused with distance in the aquifer system.

Water-level fluctuations are attenuated with increasing depth as well as with increasing horizontal distance from the recharge area. This can be seen by comparing the hydrographs of wells 21S/11E-19CCC and 22S/10E-14CCA, which are about 5 miles apart in geographically similar settings in the La Pine subbasin (fig. 34). Well 21S/11E-19CCC is 100 ft deep and produces water from a sand and gravel deposit between a depth of 95 and 100 ft. Well 22S/10E-14CCA is 555 ft deep and taps water-bearing zones between 485 and 545 ft below land surface within a thick sequence of fine-grained sediment. The water level in the well 21S/11E-19CCC was declining until early 1995 when it started to rise in response to the end of drought conditions. The water level rose over 15 ft by early 1997 in a manner similar to wells close to the Cascade Range. The water level in well 22S/10E-14CCA, in contrast, declined until early 1996, and by 1999 had risen only about 7 ft in response to the end of drought conditions.

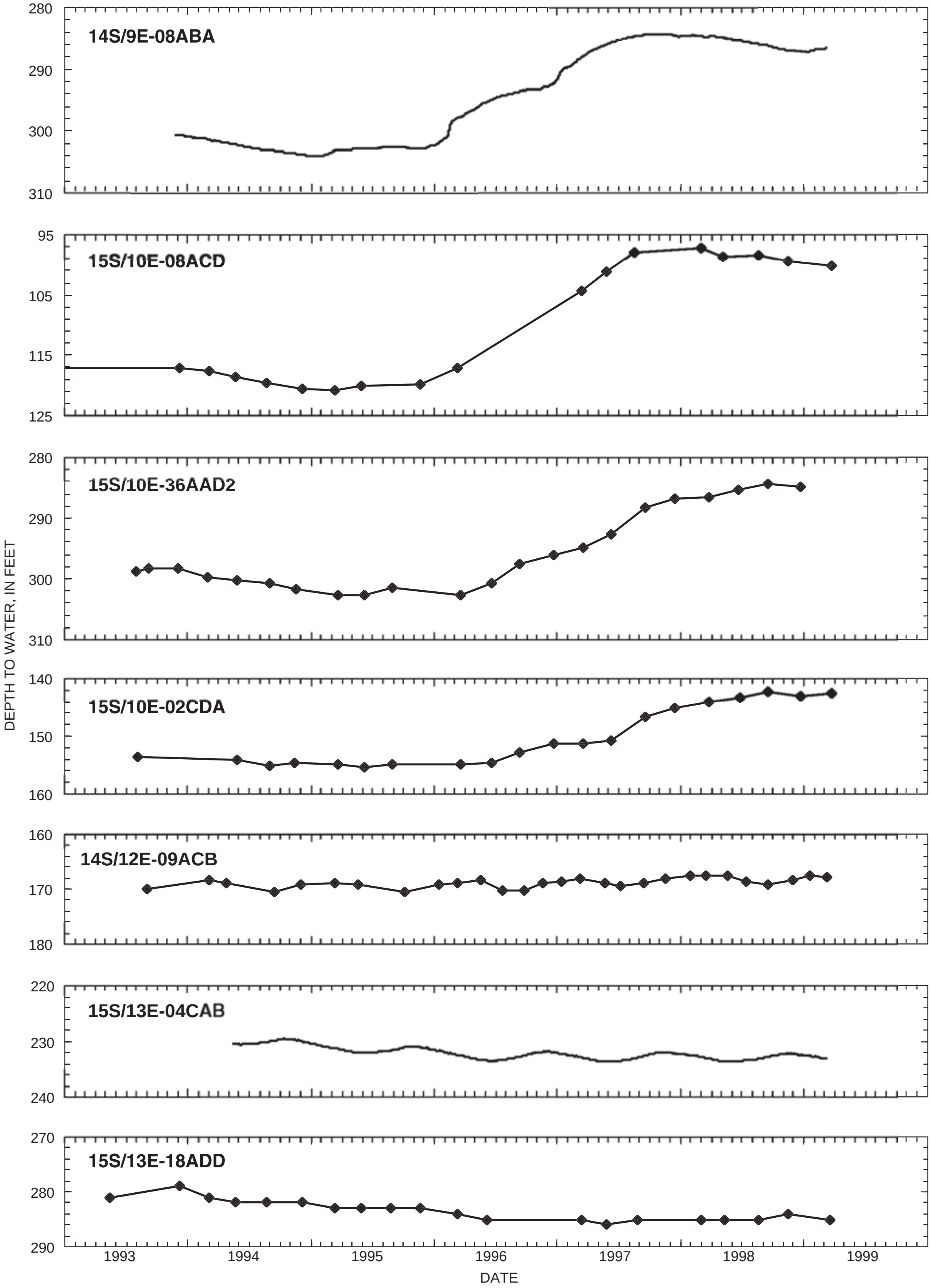

Figure 32. Variations in static water levels of selected wells at various distances from the Cascade Range, 1994–98. (The hydrographs show that the abrupt rise in water level in response to the change from drought conditions to wetter-than-normal conditions observed in the Cascade Range [uppermost hydrograph] is attenuated and delayed eastward out into the basin.)

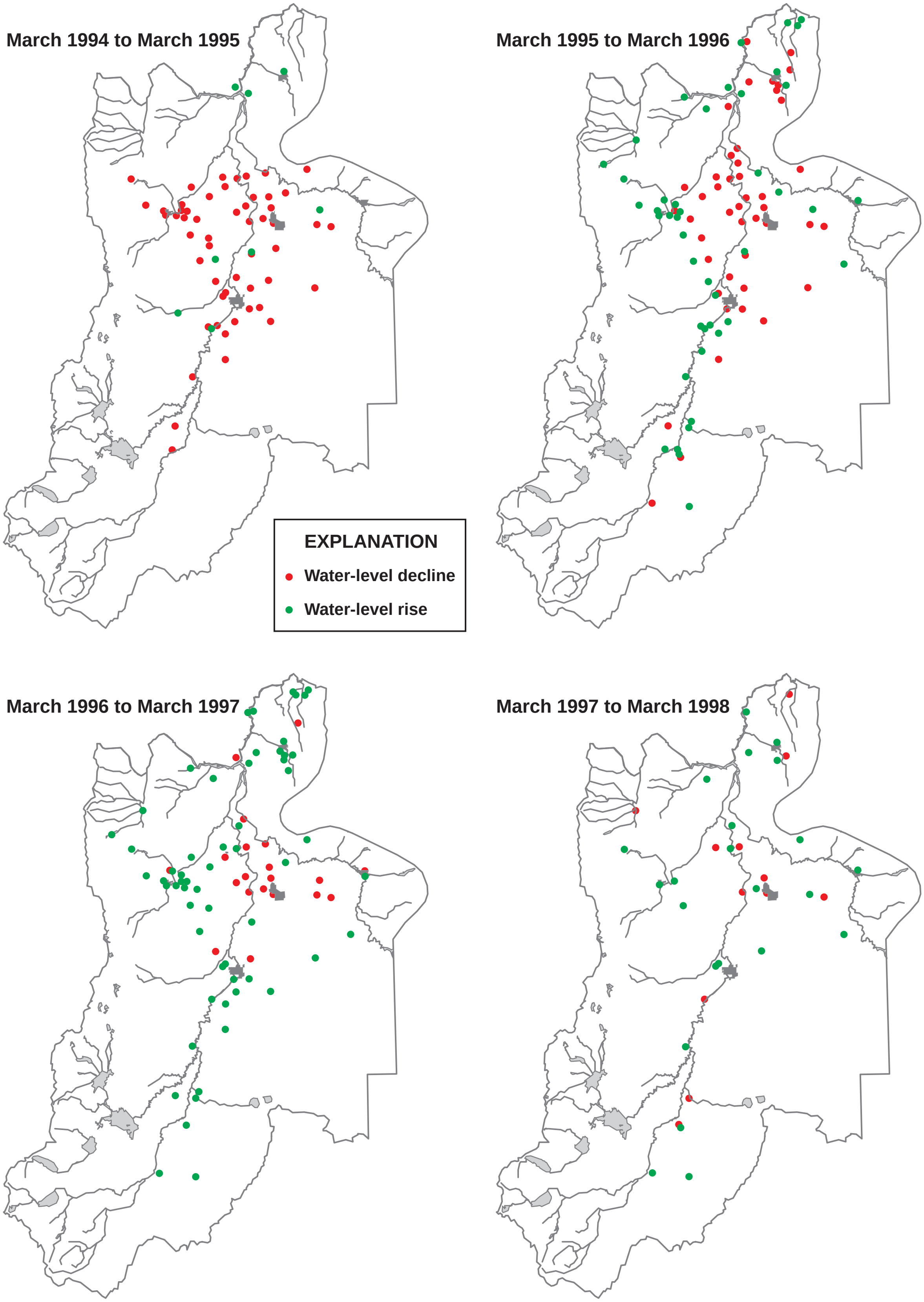

Figure 33. Year-to-year changes in March static water levels in observation wells in the upper Deschutes Basin, Oregon, 1994–98.

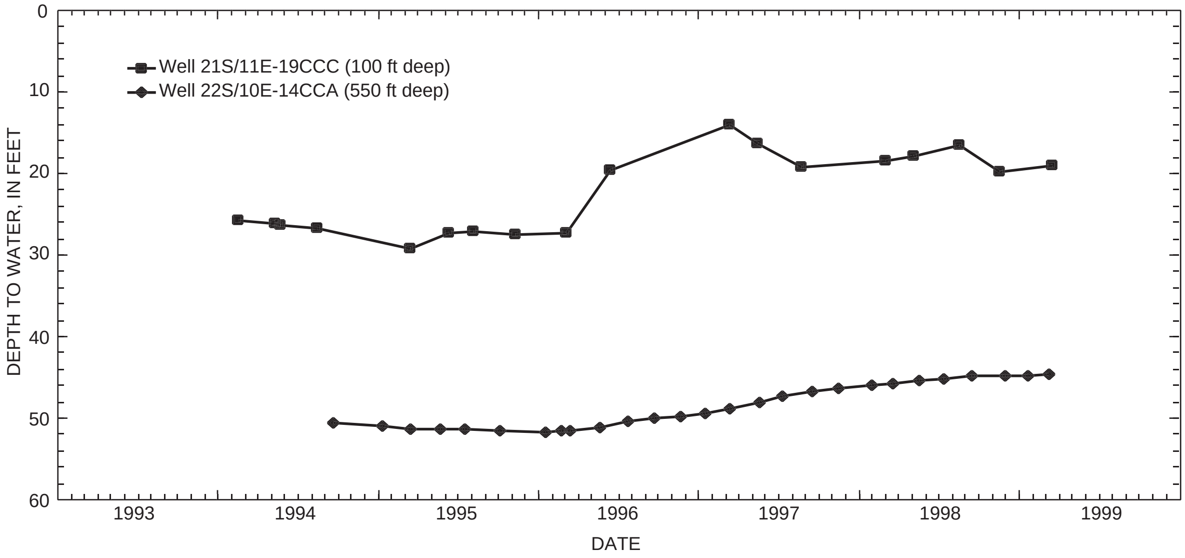

Figure 34. Static water-level variations in a shallow well and a deep well in the La Pine subbasin, Oregon.

Local-Scale Water-Table Fluctuations

In addition to basinwide ground-water-elevation fluctuations, smaller-scale, localized water-table fluctuations occur. These more isolated water-table fluctuations are caused by varying rates of recharge from local sources, such as leaking streams and canals, and by ground-water pumping.

Water-level fluctuations due to irrigation canal leakage occur in many wells throughout the irrigated areas in the central part of the study area, with water levels rising during the irrigation season when canals are flowing and dropping when canals are dry. The magnitude of these annual fluctuations varies with the proximity of the well to the canal, the depth of the well, and the local geology. Annual fluctuations due to canal leakage of nearly 100 ft have been documented (see well 17S/12E-08ABD in Caldwell and Truini (1997), p. 20), although fluctuations in the range of 1 to 10 ft are more common.

Ground-water levels can respond rapidly to canal leakage, even at considerable depths, particularly in areas where fractured lava dominates in the subsurface. The water level in well 18S/12E-03DDC responds in a matter of days to the operation of main irrigation-diversion canals, which are about one-half mile away (fig. 35). The water level in this well starts to rise shortly after the canals start flowing and starts to drop soon after they are shut off for the season, peaking late in the irrigation season. In addition, the water table responds to periods of short-term operation of the canal, typically for several days during the winter for stock watering. The static water level in well 18S/12E-03DDC is over 600 ft below land surface, and the shallowest wells in the area have water levels of 300 to 400 ft below land surface. The rapid response of the water table to canal leakage at such depth is likely due to rapid downward movement of water through interconnected vertical fractures in the lava flows.

Water-table fluctuations can be more subdued and delayed in areas underlain by sedimentary materials where there are no vertical fractures and there is more resistance to downward movement of water. Well 15S/13E-04CAB (fig. 36) shows an annual water-level fluctuation that differs substantially from that of well 18S/12E-03DDC (fig. 35). The amount of fluctuation is somewhat less and the hydrograph is smooth, nearly sinusoidal, reflecting no short-term effects due to winter stock runs. In addition, the annual peak water level in well 15S/13E-04CAB, which occurs in October or November, is much later than that of well 18S/12E-03DDC, which occurs in August or September. The hydrograph of well 15S/13E-04CAB in figure 36 also shows a year-to-year decline in water levels due to drought effects superimposed on the annual fluctuations.

Water levels are affected by variations in streamflow as well as canal operation. In areas where stream elevations are above the adjacent ground-water elevations, streams typically lose water to the ground-water system due to leakage through the streambed. In some areas, the rate of stream leakage is not constant, but varies with streamflow. As streamflow increases and the elevation of the stream rises, a larger area of the stream bed is wetted providing a larger area through which water can leak.

The most substantial stream losses measured in the basin occur along the Deschutes River between Sunriver and Bend, where the river loses, on average, about 113 ft^3/s (fig. 12). The amount of loss is known to be stage-dependent and to vary with streamflow (fig. 13). This means that the ground-water recharge in the vicinity of the Deschutes River between Benham Falls and Bend varies with streamflow as well.

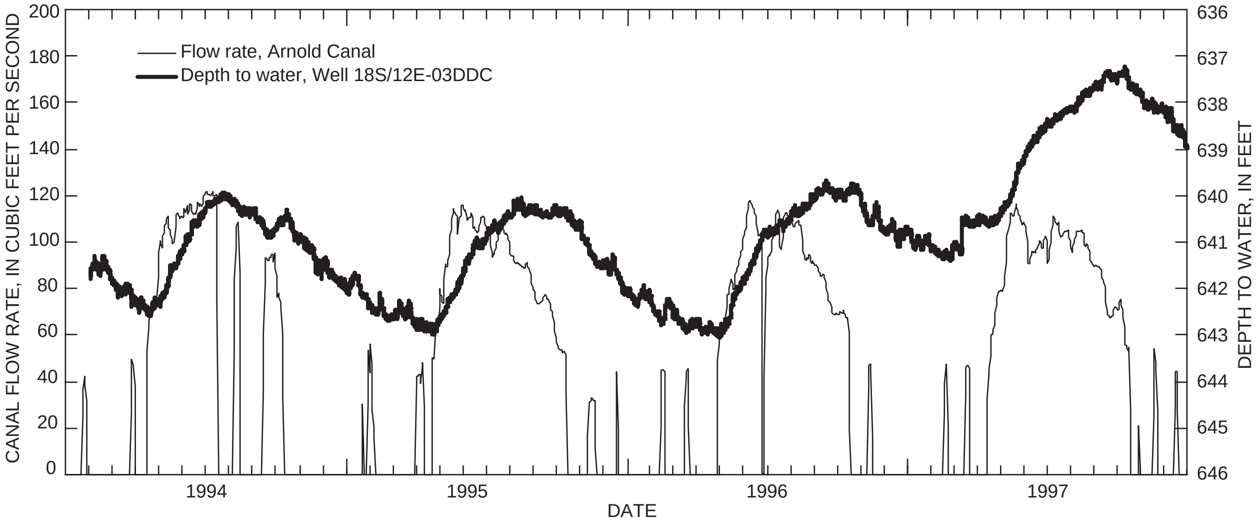

Figure 35. Relation between static water-level variations in a deep well near Bend, Oregon, and flow rate in a nearby irrigation canal.

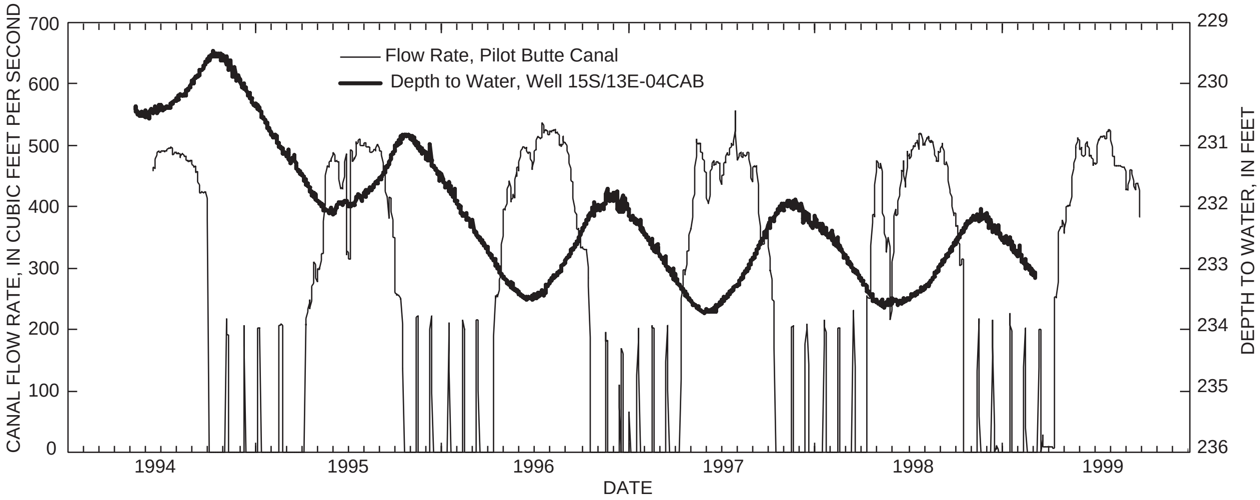

Figure 36. Relation between static water-level variations in a well near Redmond, Oregon, and flow rate in a nearby irrigation canal.

The variations in local recharge caused by changes in streamflow cause water-level fluctuations in some wells between Benham Falls and Bend (fig. 37). The stage and discharge in the Deschutes River in this reach is controlled by reservoir operations upstream. Streamflow is highest from April to October as water is re-leased from the reservoirs to canal diversions near Bend. As a result, changes in streamflow (and stage) can be relatively abrupt. The water level in well 19S/11E-16ACC, about 500 ft from the river near the Benham Falls gage, rises and falls in response to river stage (fig. 37). Abrupt changes in streamflow usually manifest in the well within a few to several days. These effects are much less pronounced, however, in wells farther from the river. The water level in well 18S/11E-21CDD, about 1 mile from the river, also fluctuates in response to river stage, but the fluctuations are subdued and the hydrograph is nearly sinusoidal, showing only the slightest inflections in response to abrupt changes in streamflow. In addition, the peaks and troughs in the hydrograph of well 18S/11E-21CDD lag those of well 19S/11E-16ACC and river stage by 1 to 2 months.

The relation between ground-water levels and streamflow is apparent in ground-water discharge areas as well as in recharge areas; however, the process is reversed. In areas of losing streams (recharge areas), streamflow variations can cause water-table fluctuations as described in the previous paragraph. In ground-water discharge areas, however, water-table fluctuations cause variations in streamflow. This is illustrated by comparing a graph of the discharge of Fall River, a spring-fed stream, with a graph of typical long-term water-table fluctuations at the Cascade Range margin as seen in well 15S/10E-08ACD (fig. 38). It can be seen that spring flow increases during periods when the water table is high, and decreases when the water table is low. This process works on a larger scale to cause the temporal variations in ground-water discharge to major streams described previously.

Water-table fluctuations can be caused by ground-water pumping as well as by variations in recharge. When a well is pumped, the water table in the vicinity of the well is lowered due to the removal of ground water from storage. A conical depression centered around the well develops on the water table (or potentiometric surface in the case of a confined aquifer) and expands until it captures sufficient discharge and/or induces enough new recharge to equal the pumping rate. After pumping ceases, the water table recovers as the aquifer returns to pre-pumping conditions. Key factors that determine the magnitude of water-table fluctuations caused by pumping are the aquifer characteristics, the rate and duration of pumping, the presence of aquifer boundaries, and the number of wells. In aquifers that have low permeability, pumping-induced water-table fluctuations can be large and even interfere with the operation of other wells. If the long-term average pumping rate exceeds the rate at which the aquifer can supply water, water levels will not recover fully and long-term water-level declines will occur.

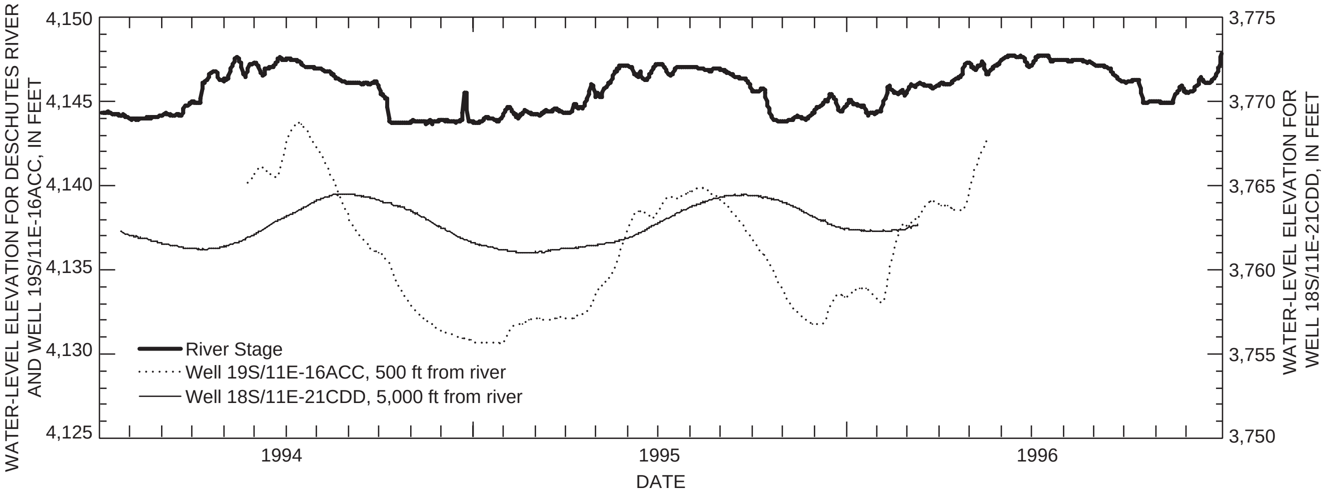

Figure 37. Relation between static water-level variations in two wells at different distances from the Deschutes River and stage of the river at Benham Falls.

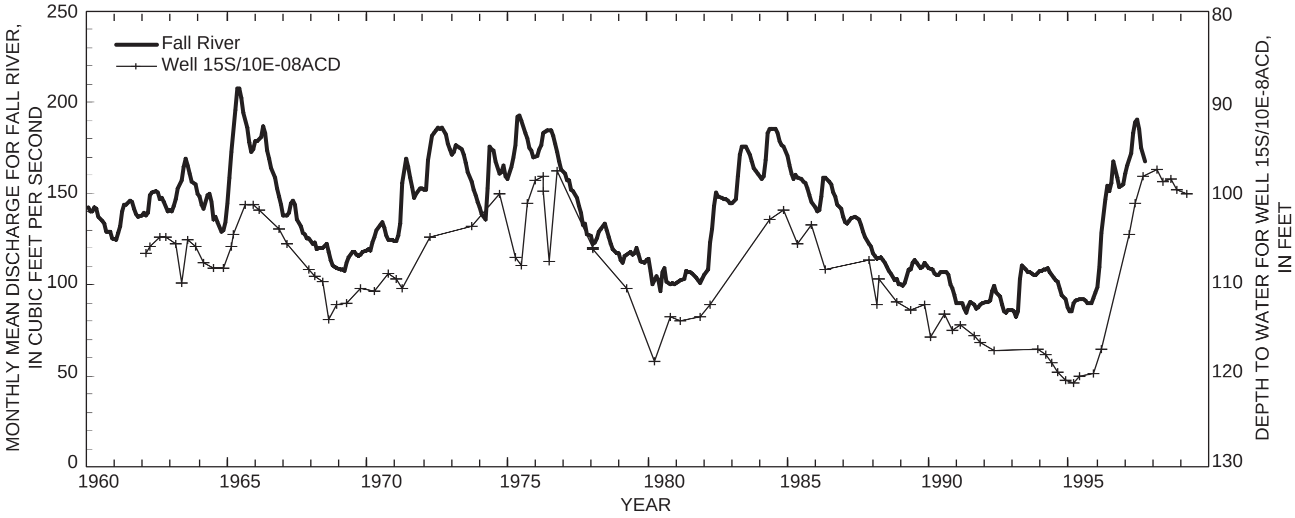

Figure 38. Relation between monthly mean discharge of Fall River and static water-level variation in a well near Sisters, Oregon, 1962–97.

Water-table fluctuations caused by ground-water pumping are apparent in only a few of the wells monitored in the upper Deschutes Basin. Pumping effects appear to be small (less than a few feet of drawdown), seasonal in nature, and of limited geographic extent. No long-term water-level declines caused by pumping are apparent in any of the data.

Nearly all of the wells that were measured quarterly and that show annual fluctuations have high water levels during or shortly after the irrigation season, indicating that the water-table fluctuation is caused by canal leakage. A few of the wells that were measured quarterly show low water levels during the summer, suggesting a possible influence from irrigation pumping, but the small number of water-level measurements prevents any definite conclusions. These occurrences are not widespread.

Of the 16 wells that had continuous water-level recorders, pumping effects are apparent only in well 14S/12E-09ACB in the Lower Bridge area (fig. 39). This unused well shows an annual cycle in which the water level drops during the irrigation season, from about April to about September, and then rises during the off season. The annual variation is approximately 2 to 3 ft. The shape of the hydrograph of this well indicates drawdown and recovery most likely due to pumping of an irrigation well about a mile away. Although irrigation pumping causes a seasonal water-level decline in this well, there is no evidence of any long-term water-level decline. The only obvious long-term water-level trend seen in the well is the basinwide trend related to climate cycles. The lack of any apparent long-term pumping effects in this well is significant, because the Lower Bridge area contains the highest concentration of irrigation wells in the basin.

Water levels in the two other centers of ground-water pumping in the basin, the Bend and Redmond areas, show no apparent influence from ground-water pumping. Large amounts of ground water are pumped in both of these areas for public water-supply use, yet no pumping-related seasonal or long-term trends are apparent in observation well data. Any pumping influence is likely small due to the high aquifer permeability, and is undetectable due to the masking effects of canal leakage and climate-driven water-level fluctuations.

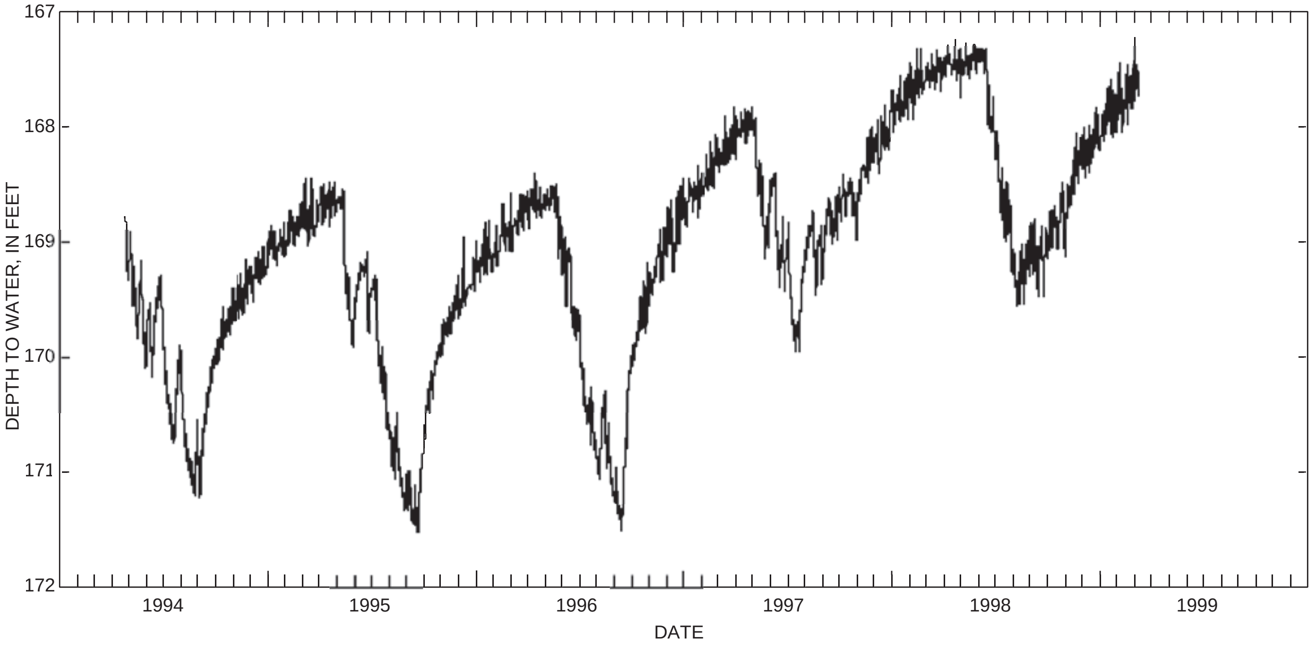

Figure 39. Static water level in an unused irrigation well near Lower Bridge (14S/12E-09ACB), showing seasonal pumping effects from nearby irrigation wells and long-term climatic effects.

Ground-water levels in part of Jefferson County rose dramatically in response to the filling of Lake Billy Chinook behind Round Butte Dam in 1964. Water levels in two wells (11S/12E-21ABB and 11S/12E-26AAC) monitored by Portland General Electric, on opposite sides of the dam and about a mile away, rose approximately 120 and 100 ft, respectively, within about 10 years of filling of the reservoir (fig. 40). Because these are the only two wells monitored in the area with records extending back to the time prior to the filling of the reservoir, the full extent and magnitude of the effects of the reservoir are not clearly known. A comparison of water-level elevations mapped by Stearns (1931) with those mapped during this study (fig. 28) suggests that water levels have risen as much as 100 ft over a fairly large region from Round Butte, south to Juniper Butte, and extending east as far as Highway 97. Increases in water-level elevation were likely even greater close to the reservoir. No data are available to evaluate the probable water-level rise west and north of the reservoir, but water levels were almost certainly similarly affected. Water levels appear to have risen north of Round Butte in the vicinity of Lake Simtustus as well, but data are sparse and the magnitude and extent of any water-level rise are unknown. Although data are scarce, water levels appear not to have been affected as far north and east as Madras. A 1953 water-level measurement in one of the city of Madras water-supply wells is comparable to measurements made recently, long after the effects of Lake Billy Chinook should have been apparent.

Some of the wells in Jefferson County show an anomalous rising water-level trend that appears to have started in the mid-1980s. The hydrograph of well 11S/12E-26AAC (fig. 40) shows that the water level appeared to have largely stabilized in response to the filling of Lake Billy Chinook by the mid 1970s, but then started an upward trend beginning about 1985, rising over 20 ft since that time. Of the four other wells in the vicinity with sufficient record, two do not show this recent rising trend (fig. 40, well 11S/12E-21ABB), and two show water level rises of approximately 2 and 6 ft. This local water-table rise is an enigma in that it occurs during a period when water levels were dropping throughout much of the upper basin as a result of drought. There are no apparent changes in irrigation practices or canal operations that could account for the observed upward trend. Water levels in wells in the Madras area rose after the city changed their primary source of water from wells to Opal Springs and greatly reduced their ground-water pumping, but this occurred in 1987, 2 years after the water level appears to have started to rise in well 11S/12E-26AAC (fig. 40). Although not entirely coincident, this reduction in pumping may have contributed to the observed water-level rise. It is also possible that the rise is a boundary effect related to the filling of Lake Billy Chinook, implying that the ground-water system is not yet in equilibrium with the reservoir even though water levels appeared to have stabilized in the late 1970s.

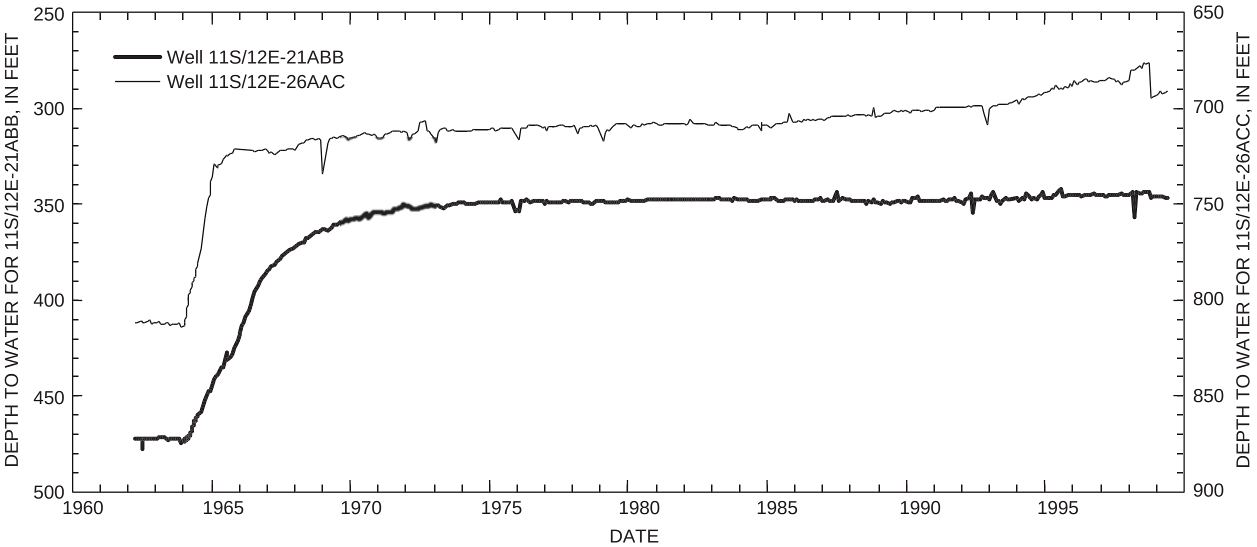

Figure 40. Water levels in two wells near Round Butte Dam, showing the rise in ground-water elevations caused by the filling of Lake Billy Chinook.

Summary and Conclusions

Regional ground-water flow in the upper Deschutes Basin is primarily controlled by the distribution of recharge, the geology, and the location and elevation of streams. Ground water flows from the principal recharge areas in the Cascade Range and Newberry Volcano, toward discharge areas along the margin of the Cascade Range and near the confluence of the Deschutes, Crooked, and Metolius Rivers.

At the regional scale, distribution of recharge mimics that of precipitation. The annual precipitation rate shows considerable geographic variation throughout the upper Deschutes Basin. The Cascade Range, which constitutes the western boundary of the basin, locally receives in excess of 200 inches per year, mostly as snow. The central part of the study area, in contrast, typically receives less than 10 inches per year. The young Quaternary volcanic deposits and thin soils in the Cascade Range allow rapid infiltration of much of the rain and snowmelt, making the Cascade Range the locus of ground-water recharge for the basin. The average annual rate of recharge from precipitation basinwide is about 3,800 ft^3/s (cubic feet per second). Precipitation provides relatively little ground-water recharge in the low-elevation areas in the central part of the basin; however, leaking irrigation canals are locally a significant source of recharge. It is estimated that 46 percent of the water diverted for irrigation is lost through canal leakage. The average annual rate of leakage from irrigation canals during 1994 was estimated to be 490 ft^3/s. Part of the ground water recharged in the Cascade Range discharges to spring-fed streams at lower elevations in the range and along margins of adjacent lowlands. The remainder of the ground water continues in the subsurface toward the central part of the basin, where most of it discharges to the Deschutes, Crooked, and Metolius Rivers in the vicinity of their confluence.

Most ground water in the upper Deschutes Basin flows through Neogene and younger deposits of the Cascade Range and Deschutes Formation. The underlying late Eocene to early Miocene deposits of the John Day Formation and the hydrothermally altered rocks at depth beneath the Cascade Range generally have very low permeability and are neither a significant source of ground water nor a medium through which it can easily flow. These older rocks crop out along the northern and eastern margins of the study area and underlie much of the upper basin at depth. Low-permeability rock units constitute the lower, northern, and eastern boundaries to the regional flow system.

The interaction between ground water and streams is controlled largely by the relative elevations of the water table and adjacent streams. In the La Pine subbasin, south of Benham Falls, the water-table elevation is near land surface. Stream gains and losses along most of the Deschutes and Little Deschutes Rivers in this area are small, indicating relatively little net exchange between ground water and surface water. North of Benham Falls, the northward slope of the water table is larger than the slope of the land surface, so depths to ground water increase northward toward Bend. In the central and eastern parts of the study area, ground-water elevations are typically hundreds of feet below the elevations of streams. Although ground-water levels are considerably below stream elevations in this area, streams do not lose appreciable amounts of water, because streambeds have been largely sealed by infiltration of fine sediment. One notable exception is the Deschutes River, which loses on average approximately 113 ft^3/s between Sunriver and Bend, likely into the youthful Holocene basalt erupted from Lava Butte.

The Deschutes and Crooked Rivers have incised canyons in the northern part of the study area. The canyons become increasingly deep northward toward Lake Billy Chinook, reaching depths of several hundred feet below the surrounding terrain. About 10 to 15 miles above their confluence, the canyons of the Deschutes and Crooked Rivers are of sufficient depth to intersect the regional water table, and both streams gain flow from ground-water discharge. Seepage runs show that the Deschutes River and lower Squaw Creek combined gain about 400 ft^3/s from ground-water discharge in this area prior to entering Lake Billy Chinook, and the lower Crooked River gains about 1,100 ft^3/s before entering the lake. Ground-water discharge to Lake Billy Chinook is roughly 420 ft^3/s. The total ground-water discharge in the confluence area is approximately 2,300 ft^3/s. This ground-water discharge, along with the flow of the Metolius River (which is predominantly ground-water discharge during the dry seasons), makes up virtually all the flow of the Deschutes River at Madras during the summer and early fall.

Geologic factors are the primary cause of the large ground-water discharge in the confluence area. The permeable Neogene deposits, through which virtually all regional ground water flows, become increasingly thin northward as the low-permeability John Day Formation nears the surface. The John Day Formation is exposed in the canyon of the Deschutes River about 10 miles north of Lake Billy Chinook near Pelton Dam, marking the northern extent of the permeable regional aquifer system. Most of the regional ground water in the upper basin discharges to the Deschutes and Crooked Rivers south of this location. There is no appreciable ground-water discharge directly to the Deschutes River downstream of this point, and the small gains in streamflow that do occur result primarily from tributary inflow.

Geological evidence and hydrologic budget calculations indicate that virtually all ground water not consumptively used in the upper Deschutes Basin discharges to the stream system upstream of the vicinity of Pelton Dam. Moreover, virtually the entire flow of the Deschutes River at Madras is supported by ground-water discharge during the summer and early fall. Ground water and surface water are, therefore, directly linked, and removal of ground water will ultimately diminish streamflow.

Analysis of the fluctuations of water-table elevations and ground-water discharge rates in response to stresses on the ground-water system, such as canal operation, stream-stage variation, and climate cycles, indicates that the effects of such stresses are delayed and attenuated with distance. The effects of ground-water pumping can be expected to be attenuated and delayed in a similar manner and spread out over time and space. Depending on the location of a well, several years may pass between the time pumping starts and the time the effects of the pumping are reflected in diminished discharge. It is important to note that the same physical processes that delay the onset of the effects of pumping on the streams also cause those effects to linger after pumping ends. So several years may also pass between the time pumping stops and the time the effects on streamflow end.

Presently, the effects of pumping cannot be measured below the confluence of the Deschutes, Crooked, and Metolius Rivers. The total consumptive use of ground water in the upper Deschutes Basin as of the mid-1990s is estimated to be about 30 ft^3/s: 20 ft^3/s for irrigations and 10 ft^3/s for public water supplies (assuming 50 percent of public-supply pumpage is consumptively used). Streamflow at the Madras gage, which is largely ground-water discharge during the summer, is about 4,000 ft^3/s. Streamflow measurement techniques used at the gage have an accuracy of ±5 percent, resulting in a range of error of about ±200 ft^3/s. Because total estimated consumptive ground-water use is less than 1 percent of the ground-water discharge at Madras, it is well within the expected range of measurement error. The amount of ground-water use also is small compared to the observed natural fluctuations in ground-water discharge. Streamflow in the Deschutes Basin fluctuates dramatically at a variety of time scales due to many factors, including runoff variations, reservoir and canal operation, and climate cycles. The ground-water component of streamflow also fluctuates widely. For example, August mean ground-water discharge to the Deschutes River between Bend and Culver varied over 100 ft^3/s between 1962 and 1997 due to climate cycles. The August mean flow of the Crooked River below Opal Springs, which is mostly ground-water discharge, varied 460 ft^3/s during the same period. Ground-water discharge to the Metolius River, based on October mean flows, varied over 400 ft^3/s from 1962 to 1997. Combined, these climate-driven ground-water discharge fluctuations could account for variations in late-season monthly mean flows of the Deschutes River at Madras on the order of 1,000 ft^3/s. Natural fluctuations of ground-water discharge of this magnitude in the confluence area totally mask the effects of ground-water withdrawal at present levels of development.

Although the effects of historic ground-water pumping cannot be measured below the confluence area, the effects of canal leakage are easily discernible in the streamflow records. The August mean flows of the lower Crooked River increased between the early 1900s and the early 1960s by roughly 400 to 500 ft^3/s in a manner that paralleled the increase in estimated canal leakage north of Bend during the same period. The correlation indicates that a large proportion of the water lost from leaking irrigation canals north of Bend is discharging to the lower Crooked River upstream of the Opal Springs gage. This is consistent with the hydraulic-head distribution and ground-water flow directions in the area.

Although the effects of historic ground-water pumping on streamflow cannot be discerned in the streamflow record below the confluence area, it is possible that such effects could be measurable on smaller streams in the upper Deschutes Basin. Most tributary streams emanating from the Cascade Range, such as Fall River, Squaw Creek, and Indian Ford Creek, are either spring fed or otherwise hydraulically connected to the ground-water system. The ground-water discharge to these streams, and consequently streamflow, could be diminished to a measurable degree depending on the amount of ground-water pumping and the proximity of pumping to the stream. Long-term streamflow records, however, are not available to assess possible effects of historic ground-water development on smaller streams. Streamflow records are available for only a small number of tributary streams in the upper Deschutes Basin, and the gages that are operated are generally not in locations where the impacts of ground-water pumping are likely to be detected given the present geographic pattern of development.

Some stream reaches, for example the Deschutes River between Bend and Lower Bridge, are perched above the ground-water system. Although leakage from such streams can provide recharge to the ground-water system, the rate of leakage is independent of ground-water elevation changes. Therefore, ground-water pumping will have little or no affect on the rate of leakage along such reaches.

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SITE_INFO

Field Name	Field Description
AgencyCd	Code for the name of the agency or organization that owns the site and/or contributed it to the network
SiteNo	Local, unique well or spring identification number or code
AgencyNm	Full name of the agency or organization that collects, owns and/or manages the data
SiteName	Local name of well or spring
DecLatVa	Latitude, in decimal degrees
DecLongVa	Longitude, in decimal degrees (negative for Western Hemisphere)
HorzDatum	Horizontal reference datum code for the latitude and longitude of a well
AltVa	Elevation of the land surface at the site
AltUnits	Code for unit of measure associated with the AltVa field
AltUnitsNm	Name of unit of measure associated with the AltVa field
AltDatumCd	Vertical reference datum code for the altitude of a well
WellDepth	Depth of the well from a specified point of reference
WellDepthUnits	Code for unit of measure associated with the WellDepth field
WellDepthUnitsNm	Name for unit of measure associated with the WellDepth field
NatAquiferCd	Code for U.S. Principal Aquifer
NatAqfrDesc	Name of U.S. Principal Aquifer
LocalAquiferCd	Code for local aquifer
LocalAquiferName	Name of local aquifer
CountryCd	Abbreviation for country
CountryNm	Name of country
StateCd	FIPS code for state
StateNm	Name of state
CountyCd	FIPS code for county
CountyNm	Name of county
WlSysName	Name of the system from which water-level data associated the well or spring is served to the portal
WlSnFlag	Flag for whether the well or spring is part of the water-level network (1,‘Yes’; ‘0’,’No’)
WlSnDesc	Description of the flag for whether the well or spring is part of the water-level network
WlBaselineFlag	Flag for whether the well or spring has completed its 5-year baseline period, necessary to classify it as being in one of the three WL subnetworks (1,‘Yes’; ‘0’,’No’)
WlBaselineDesc	Description of whether the well or spring has completed its 5-year baseline period, necessary to classify it as being in one of the three WL subnetworks
WlWellChars	Code for WL subnetwork that the well or spring is part of (‘1’,’Background’;’2’,’ Suspected / Anticipated Changes’;’3’,’Demonstrated Changes’)
WlWellCharsDesc	Description of the WL subnetwork that the well or spring is part of
WlWellType	Code for the assigned WL monitoring category for the well or spring (‘1’,’Surveillance’;’2’,’Trend’;’3’,’Special’)
WlWellTypeDesc	Description of the assigned WL monitoring category for the well or spring

WlWellPurpose	Code for the purpose of conducting WL monitoring of the well or spring (‘1’,’ Dedicated Monitoring/Observation’;’2’,’Other’)
WlWellPurposeDesc	Description of the purpose of conducting WL monitoring of the well or spring
WlWellPurposeNotes	Additional notes about the purpose for conducting WL monitoring of the well or spring
QwSysName	Name of the system from which water-quality data associated the well or spring is served to the portal
QwSnFlag	Flag for whether the well or spring is part of the water-quality network (1,‘Yes’; ‘0’,’No’)
QwSnDesc	Description of the flag for whether the well or spring is part of the water-quality network
QwBaselineFlag	Flag for whether the well or spring has completed its 5-year baseline period, necessary to classify it as being in one of the three QW subnetworks (1,‘Yes’; ‘0’,’No’)
QwBaselineDesc	Description of whether the well or spring has completed its 5-year baseline period, necessary to classify it as being in one of the three QW subnetworks
QwWellChars	Code for QW subnetwork that the well or spring is part of (‘1’,’Background’;’2’,’ Suspected / Anticipated Changes’;’3’,’Demonstrated Changes’)
QwWellCharsDesc	Description of the QW subnetwork that the well or spring is part of
QwWellType	Code for the assigned QW monitoring category for the well or spring (‘1’,’Surveillance’;’2’,’Trend’;’3’,’Special’)
QwWellTypeDesc	Description of the assigned QW monitoring category for the well or spring
QwWellPurpose	Code for the purpose of conducting QW monitoring of the well or spring (‘1’,’ Dedicated Monitoring/Observation’;’2’,’Other’)
QwWellPurposeDesc	Description of the purpose of conducting QW monitoring of the well or spring
QwWellPurposeNotes	Additional notes about the purpose for conducting QW monitoring of the well or spring
SiteType	Type of groundwater site (Well or Spring)
AquiferType	Characteristic of the type of aquifer that the well is completed in (Confined or Unconfined). For the NGWMN, shallow semi-confined wells can be considered to be unconfined if they respond to climatic fluctuations in a relatively short period of time
LithDataProvider	Code for the name of the agency or organization that provides, collects, owns and/or manages the lithology dataset
ConstDataProvider	Code for the name of the agency or organization that provides, collects, owns and/or manages the construction dataset
Link	Link for additional information about the site from the Data Provider

CASING

Field Name	Field Description
AgencyCd	Code for the name of the agency or organization that owns the site and/or contributed it to the network
SiteNo	Local, unique well or spring identification number or code
CasingDepthFrom	Beginning depth of cased interval
CasingDepthFromUnit	Code for unit of measure associated with the CasingDepthFrom field

CasingDepthTo	Ending depth of screened interval
CasingDepthToUnit	Code for unit of measure associated with the CasingDepthTo field
CasingMaterial	Screen type or material
CasingDiameter	Internal diameter of casing
CasingDiameterUnit	Code for unit of measure associated with the CasingDiameter field

SCREEN

Field Name	Field Description
AgencyCd	Code for the name of the agency or organization that owns the site and/or contributed it to the network
SiteNo	Local, unique well or spring identification number or code
ScreenDepthFrom	Beginning depth of screened interval
ScreenDepthFromUnit	Code for unit of measure associated with the ScreenDepthTo field
ScreenDepthTo	Ending depth of screened interval
ScreenDepthToUnit	Code for unit of measure associated with the ScreenDepthFrom field
holeSize	With of the openings in the screen
holeSizeUnit	Code for unit of measure associated with the holeSize field
ScreenMaterial	Screen type or material
ScreenDiameter	Internal diameter of the screen
ScreenDiameterUnit	Code for unit of measure associated with the ScreenDiameter field

LITHOLOGY

Field Name	Field Description
AgencyCd	Code for the name of the agency or organization that owns the site and/or contributed it to the network
SiteNo	Local, unique well or spring identification number or code
LithologyID	Code for the type of lithology or geology of the unit
LithologyDescription	Description of the type of lithology or geology of the unit
ObservationMethod	Method for classifying lithology or geology of the unit
LithologyDepthFrom	Beginning depth of the lithologic unit
LithologyDepthTo	Ending depth of the lithologic unit

WATERLEVEL

Field Name	Field Description
AgencyCd	Code for the name of the agency or organization that owns the site and/or contributed it to the network
SiteNo	Local, unique well or spring identification number or code
Time	Date and time of the water-level measurement
Original Parameter	Original or native parameter code for the water-level measurement
Original Direction	Direction with respect to land surface of original or native positive water-level measurements

Original Unit	Original or native unit of measure associated with the ‘Original Value’ field
Original Value	Original or native value of water-level
Depth to Water Below Land Surface in ft.	Mediated water-level value represented as depth to water below land surface in feet
Observation Method	The observation method associated with the original or native water-level measurement
Data Provided by	Code for the name of the agency or organization that provides, collects, owns and/or manages the water level measurement record

QUALITY

Field Name	Field Description
AgencyCd	Code for the name of the agency or organization that owns the site and/or contributed it to the network
SiteNo	Local, unique well or spring identification number or code
Date	Date of the water quality sample collection
Time	Time of day of the water quality sample collection
TimeZone	The time zone for which the time of day is reported
CharacteristicName	The object, property, or substance which is evaluated or enumerated by either a direct field measurement, a direct field observation, or by laboratory analysis of material collected in the field
Value	The reportable measure of the result for the chemical, microbiological or other characteristic being analyzed
Unit	The code that represents the unit for measuring the value
Result Status	Indicates the acceptability of the result with respect to QA/QC criteria
Value Type	A name that qualifies the process, which was used in the determination of the result value (e.g., actual, estimated, calculated)
USGS PCode	5-digit number used in the US Geological Survey computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent
Sample Fraction	The text name of the portion of the sample associated with results obtained from a physically-partitioned sample
Result Comment	Free text with general comments concerning the result.
Temperature Basis	The name that represents the controlled temperature at which the sample was maintained during analysis, e.g. 25 deg BOD analysis
Detection Condition	The textual descriptor of a result
Method Identifier	The identification number or code assigned by the method publisher
Method Context	Identifies the source or data system that created or defined the identifier
Method Name	The title that appears on the method from the method publisher
Method Description	A brief summary that provides general information about the method
Quantitation Limit Type	Text describing the type of detection or quantitation level used in the analysis of a characteristic
Quantitation Limit Value	Constituent concentration that, when processed through the complete method, produces a signal that is statistically different from a blank
Quantitation Limit Unit	The code that represents the unit for measuring the item
Data Provided by	Code for the name of the agency or organization that provides, collects, owns and/or manages the sample record

NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report
are to be filed with the

WATER RESOURCES DEPARTMENT,
SALEM, OREGON 97310
within 30 days from the date
of well completion.

RECEIVED
MAY 8 1979
WATER RESOURCES DEPT.
SALEM, OREGON

WATER WELL REPORT
STATE OF OREGON
(Please type or print)
(Do not write above this line)

DESC
3954

State Well No. 15S/13E -23

State Permit No.

(1) OWNER:

Name Military Dept., State of Oregon
Address 2150 Fairgrounds Rd., N.E.
Salem, Oregon 97303

(2) TYPE OF WORK (check):

New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐

If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:

Rotary ☒ Driven ☐
Cable ☒ Jetted ☐
Dug ☐ Bored ☐

(4) PROPOSED USE (check):

Domestic ☐ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☒

[illegible] CASING INSTALLED:

Threaded ☐ Welded ☒

6 " Diam. from +2 ft. to 362 ft. Gage .250
" Diam. from ft. to ft. Gage
" Diam. from ft. to ft. Gage

[illegible]) PERFORATIONS:

Perforated? ☐ Yes ☒ No.

Type of perforator used
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS:

Well screen installed? ☒ Yes ☐ No

Manufacturer's Name Johnson
Type Telescopic Model No. 10 slot
Diam. 6" Slot size 10 Set from 378 ft. to 420 ft.
Diam. Slot size Set from ft. to ft.

(8) WELL TESTS:

Drawdown is amount water level is lowered below static level

Was a pump test made? ☒ Yes ☐ No If yes, by whom? Contractor
Yield: 30 gal./min. with 0 ft. drawdown after 1 hrs.
" " " "
" " " "
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m.
Temperature of water 53° Depth artesian flow encountered ft.

(9) CONSTRUCTION:

Well seal—Material used cement
Well sealed from land surface to 25 ft.
Diameter of well bore to bottom of seal 10 in.
Diameter of well bore below seal 8 in.
Number of sacks of cement used in well seal 16 sacks
How was cement grout placed? pressure grout

Was a drive shoe used? ☐ Yes ☒ No Plugs Size: location ft.
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? depth of strata
Method of sealing strata off
Was well gravel packed? ☐ Yes ☒ No Size of gravel:
Gravel placed from ft. to ft.

(10) LOCATION OF WELL:

County Deschutes Driller's well number
¼ N½ ¼ Section 23 T. 15S R. 13E. W.M.
Bearing and distance from section or subdivision corner

(11) WATER LEVEL: Completed well.

Depth at which water was first found 390 ft.
Static level 375 ft. below land surface. Date 2-20-79
Artesian pressure lbs. per square inch. Date

(12) WELL LOG:

Diameter of well below casing 8"
Depth drilled 425 ft. Depth of completed well 420 ft.

Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level and indicate principal water-bearing strata.

MATERIAL	From	To	SWL
Top-Soil	0	4	
Lava	4	107	
Brown Conglom.	107	113	
Lava	113	143	
Brown Sandstone Conglom.	143	154	
Lava	154	200	
Broken Lava & Crevices	200	210	
Lava	210	215	
Brown Conglom.	215	224	
Lava	224	283	
Brown Sandstone	283	320	
Black Sand	320	350	
Brown Sandstone Conglom.	350	390	
Black Sand, Water-Bearing	390	425	

Work started 10-30 1978 Completed 2-16 1979
Date well drilling machine moved off of well 2-28 1979

Drilling Machine Operator's Certification:

This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.

[Signed] William D. [illegible] Date 5-3, 1979
(Drilling Machine Operator)
Drilling Machine Operator's License No. 803

Water Well Contractor's Certification:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Name Orvail Buckner Well Drilling, Inc.
(Person, firm or corporation) (Type or print)
Address 1686 N.E. Negus Way, Redmond, Oregon 97756
[Signed]
(Water Well Contractor)
Contractor's License No. 608 Date 5-3-79, 19

(USE ADDITIONAL SHEETS IF NECESSARY)

SP*45656-119

DESC 59860

Page 1 of 1

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765 & OAR 690-205-0210)

DESC 59860
12/18/2013

WELL I.D. LABEL# L 109645
START CARD # 1021578
ORIGINAL LOG #

(1) LAND OWNER

Owner Well I.D.
First Name Last Name
Company OREGON MILITARY DEPARTMENT
Address P.O. BOX 14350
City SALEM State OR Zip 97309-5047

(2) TYPE OF WORK

☒ New Well ☐ Deepening ☐ Conversion
☐ Alteration (complete 2a & 10) ☐ Abandonment(complete 5a)

(2a) PRE-ALTERATION

	Dia	+	From	To	Gauge	Stl	Plstc	Wld	Thrd
Casing:		☐				○	○	☐	☐

	Material	From	To	Amt	sacks/lbs
Seal:					

(3) DRILL METHOD

☒ Rotary Air ☐ Rotary Mud ☒ Cable ☐ Auger ☐ Cable Mud
☐ Reverse Rotary ☐ Other

(4) PROPOSED USE

☒ Domestic ☐ Irrigation ☐ Community
☐ Industrial/ Commericial ☐ Livestock ☐ Dewatering
☐ Thermal ☐ Injection ☐ Other

(5) BORE HOLE CONSTRUCTION

Special Standard ☐ (Attach copy)
Depth of Completed Well 600.00 ft.

BORE HOLE			SEAL				
Dia	From	To	Material	From	To	Amt	sacks/ lbs
15	0	59	Cement	0	59	36	S
10	59	503					
8	503	600					

How was seal placed: Method ☐ A ☐ B ☒ C ☐ D ☐ E
☐ Other
Backfill placed from ft. to ft. Material
Filter pack from ft. to ft. Material Size
Explosives used: ☐ Yes Type Amount

(5a) ABANDONMENT USING UNHYDRATED BENTONITE

Proposed Amount Actual Amount

(6) CASING/LINER

Casing	Liner	Dia	+	From	To	Gauge	Stl	Plstc	Wld	Thrd
●	○	10	☒	1	59	.250	●	○	☒	☐
○	●	8	☒	1	432	.250	●	○	☒	☐
○	●	5.56	☐	432	512	.188	●	○	☒	☐
○	●	5.63	☐	597	600	.188	●	○	☒	☐
○	○		☐				○	○	☐	☐

Shoe ☐ Inside ☐ Outside ☐ Other Location of shoe(s)
Temp casing ☐ Yes Dia From To

(7) PERFORATIONS/SCREENS

Perforations Method
Screens Type Wire Wrap Material Stainless

Perf/ Screen	Casing/ Liner	Screen Dia	From	To	Scrn/slot width	Slot length	# of slots	Tele/ pipe size
Screen	Liner	5.63	517	597	.02			5.63

(8) WELL TESTS: Minimum testing time is 1 hour

[✓ Pump] ○ Bailer ○ Air ○ Flowing Artesian

Yield gal/min	Drawdown	Drill stem/Pump depth	Duration (hr)
26	.5'	508'	4

Temperature 54 °F Lab analysis ☒ Yes By Umpqua Labs
Water quality concerns? ☐ Yes (describe below) TDS amount

From	To	Description	Amount	Units

(9) LOCATION OF WELL (legal description)

County DESCHUTES Twp 15.00 S N/S Range 13.00 E E/W WM
Sec 23 SE 1/4 of the NE 1/4 Tax Lot 116
Tax Map Number Lot
Lat ° ' " or 44.25600000 DMS or DD
Long ° ' " or -121.13300000 DMS or DD
● Street address of well ○ Nearest address

2899 HIGHWAY 126 EAST
REDMOND, OREGON 97756

(10) STATIC WATER LEVEL

	Date	SWL(psi)	+	SWL(ft)
Existing Well / Pre-Alteration			☐	
Completed Well	10/30/2013		☐	341

Flowing Artesian? ☐ Dry Hole? ☐

WATER BEARING ZONES Depth water was first found 341.00

SWL Date	From	To	Est Flow	SWL(psi)	+	SWL(ft)
10/30/2013	341	600	250		☐	341
					☐	
					☐	
					☐	
					☐	

RECEIVED BY OWRD
APR 18 2014
SALEM, OR

(11) WELL LOG

Ground Elevation 3055.00

Material	From	To
Top Soil & Broken Rock	0	1
Hard Gray Basalt	1	75
Hard Gray Basalt with some fractures	75	97
Broken Gray Basalt	97	101
Hard Gray Basalt	101	140
Brown Sandstone	140	165
Broken Lava & Pumice	165	180
Lost Circulation Void	180	190
Medium Soft?	190	205
Loose Soft Broken	205	210
Hard Gray Basalt?	210	236
Broken?	236	244
Firm to Soft	244	273
Return Back Brown Sandstone	273	313
Red Cinders Brown & Black Sandstone	313	342
Fine Black Sand	342	425
Black Sandstone	425	486
Brown Sandstone Tuft	486	515
Brown Sandstone with some Gravel Layers	515	600

Date Started 11/1/2013 Complete 12/5/2013

(unbonded) Water Well Constructor Certification

I certify that the work I performed on the construction, deepening, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

License Number Date

Signed

(bonded) Water Well Constructor Certification

I accept responsibility for the construction, deepening, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

License Number 1385 Date 12/18/2013

Signed ROBERT BUCKNER (E-filed)

Contact Info (optional)

ORIGINAL - WATER RESOURCES DEPARTMENT

THIS REPORT MUST BE SUBMITTED TO THE WATER RESOURCES DEPARTMENT WITHIN 30 DAYS OF COMPLETION OF WORK Form Version:

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765 & OAR 690-205-0210)

DESC 61209
6/20/2018

WELL I.D. LABEL# L	
START CARD #	1038948
ORIGINAL LOG #	DESCHUTES 3954

(1) LAND OWNER

Owner Well I.D.
First Name BRUCE Last Name VOLLSTEDT
Company OREGON MILITARY DEPT
Address 2899 E HWY 126 REDMOND, OR 97756
City REDMOND State OR Zip 97756

(2) TYPE OF WORK

☐ New Well ☐ Deepening ☐ Conversion
☐ Alteration (complete 2a & 10) ☒ Abandonment(complete 5a)

(2a) PRE-ALTERATION

	Dia	+	From	To	Gauge	Stl	Plstc	Wld	Thrd
Casing:		☐				○	○	☐	☐

	Material	From	To	Amt	sacks/lbs
Seal:					

(3) DRILL METHOD

☐ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger ☐ Cable Mud
☐ Reverse Rotary ☒ Other NONE

(4) PROPOSED USE

☒ Domestic ☐ Irrigation ☐ Community
☐ Industrial/ Commericial ☐ Livestock ☐ Dewatering
☐ Thermal ☐ Injection ☐ Other

(5) BORE HOLE CONSTRUCTION

Special Standard ☒ (Attach copy)
Depth of Completed Well 394.00 ft.

BORE HOLE		
Dia	From	To
6	0	394

SEAL				
Material	From	To	Amt	sacks/ lbs
		Calculated		
		Calculated		

How was seal placed: Method ☐ A ☐ B ☒ C ☐ D ☐ E
☐ Other
Backfill placed from 0 ft. to 394 ft. Material CEMENT
Filter pack from ft. to ft. Material Size
Explosives used: ☐ Yes Type Amount

(5a) ABANDONMENT USING UNHYDRATED BENTONITE

Proposed Amount Actual Amount

(6) CASING/LINER

Casing	Liner	Dia	+	From	To	Gauge	Stl	Plstc	Wld	Thrd
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐

Shoe ☐ Inside ☐ Outside ☐ Other Location of shoe(s)
Temp casing ☐ Yes Dia From + ☐ To

(7) PERFORATIONS/SCREENS

Perforations Method
Screens Type Material

Perf/ Screen	Casing/ Liner	Screen Dia	From	To	Scrn/slot width	Slot length	# of slots	Tele/ pipe size

(8) WELL TESTS: Minimum testing time is 1 hour

○ Pump ○ Bailer ○ Air ○ Flowing Artesian

Yield gal/min	Drawdown	Drill stem/Pump depth	Duration (hr)

Temperature 56 °F Lab analysis ☐ Yes By
Water quality concerns? ☐ Yes (describe below) TDS amount 72 ppm

From	To	Description	Amount	Units

(9) LOCATION OF WELL (legal description)

County DESCHUTES Twp 15.00 S N/S Range 13.00 E E/W WM
Sec 23 SW 1/4 of the NE 1/4 Tax Lot 1500
Tax Map Number Lot
Lat ° ' " or 44.25583899 DMS or DD
Long ° ' " or -121.13438983 DMS or DD
● Street address of well ○ Nearest address
2899 E HWY 126 REDMOND OR 97754

(10) STATIC WATER LEVEL

	Date	SWL(psi)	+	SWL(ft)
Existing Well / Pre-Alteration			☐	
Completed Well			☐	

Flowing Artesian? ☐ Dry Hole? ☐

WATER BEARING ZONES Depth water was first found

SWL Date	From	To	Est Flow	SWL(psi)	+	SWL(ft)
					☐	
					☐	
					☐	
					☐	
					☐	

(11) WELL LOG

Ground Elevation

Material	From	To
Pump Cement 3 yards or 66 Sacks	0	394

Date Started 5/23/2018 Completed 6/20/2018

(unbonded) Water Well Constructor Certification

I certify that the work I performed on the construction, deepening, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

License Number 1255 Date 6/20/2018
Signed WILLIAM AIKEN (E-filed)

(bonded) Water Well Constructor Certification

I accept responsibility for the construction, deepening, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

License Number 1970 Date 6/20/2018
Signed NEIL FAGEN (E-filed)
Contact Info (optional) 541-548-1245

WATER SUPPLY WELL REPORT - Map with location identified must be attached and shall include an approximate scale and north arrow

DESC 61209

DESC 61209

6/20/2018

Map of Hole

STATE OF OREGON
WELL LOCATION MAP

This map is supplemental to the WATER SUPPLY WELL REPORT

Oregon Water Resources Department
725 Summer St NE, Salem OR 97301
(503)986-0900

OREGON WATER RESOURCES DEPARTMENT

LOCATION OF WELL

Latitude: 44.2558389897 Datum: WGS84

Longitude: -121.13438982577

Township/Range/Section/Quarter-Quarter Section:

WM 15S 13E 23 SWNE

Address of Well:

2899 E HWY 126 REDMOND OR 97754

Startcard: 1038948

Printed: June 20, 2018

DISCLAIMER: This map is intended to represent the approximate location the well. It is not intended to be construed as survey accurate in any manner.

Provided by well constructor

wl_county_code	wl_nbr	wl_version	well_tag_nbr	name_last	name_first	name_mi
DESC	3954	1				
DESC	59860	1	109645			
DESC	61209	1		VOLLSTEDT	BRUCE	

name_company	street	city	state	zip
STATE OF OREGON; MILITARY DEPT.	2150 FAIRGROUNDS RD NE	SALEM	OR	97303
OREGON MILITARY DEPARTMENT	P.O. BOX 14350	SALEM	OR	97301
OREGON MILITARY DEPT	2899 E HWY 126 REDMOND, OR 97756	REDMOND	OR	97756

type_of_log	depth_first_water	depth_drilled	completed_depth	post_static_water_level	start_date
W	390	425	420	375	10/30/1978
W	341	600	600	341	11/1/2013
W		394	394		5/23/2018

complete_date	received_date	startcard_nbr	bonded_license_nbr	work_new	work_abandonment
2/20/1979	5/8/1979		608	X	
12/5/2013	12/18/2013	1021578	1385	X	
6/20/2018	6/20/2018	1038948	1970		X

work_deepening	work_alteration	work_conversion	work_other	use_domestic	use_irrigation
				X	
				X	

use_community	use_livestock	use_industrial	use_injection	use_thermal	use_dewatering	use_piezometer

use_other	township	township_char	range	range_char	sctn	qtr160	qtr40	tax_lot
	15	S	13	E	23	NE		
	15	S	13	E	23	NE	SE	116
	15	S	13	E	23	NE	SW	1500

street_of_well	location_county	longitude	latitude
	DESC		
2899 HIGHWAY 126 EAST REDMOND, OREGON 97756	DESC	-121.133	44.256
2899 E HWY 126 REDMOND OR 97754	DESC	-121.1343898	44.25583899

bonded_name_last	bonded_name_first	bonded_name_company	max_yield
BUCKNER	ORVAIL	ORVAIL BUCKNER WELL DRILLING	30
BUCKNER	ROBERT	WESTERN WATER DEVELOPMENT	26
FAGEN	NEIL	AIKEN WELL DRILLING INC.	

U.S. Fish and Wildlife Service

National Wetlands Inventory

COUTES Wetlands Map

November 13, 2018

Wetlands

🟦 Estuarine and Marine Deepwater

🟩 Estuarine and Marine Wetland

🟩 Freshwater Emergent Wetland

🟩 Freshwater Forested/Shrub Wetland

🟦 Freshwater Pond

🟪 Lake

🟫 Other

🟦 Riverine

COUTES
Site: 41902

N
W E
S

OREGON MILITARY DEPARTMENT

0 50100 200 300 400
Feet

1 inch = 200 feet

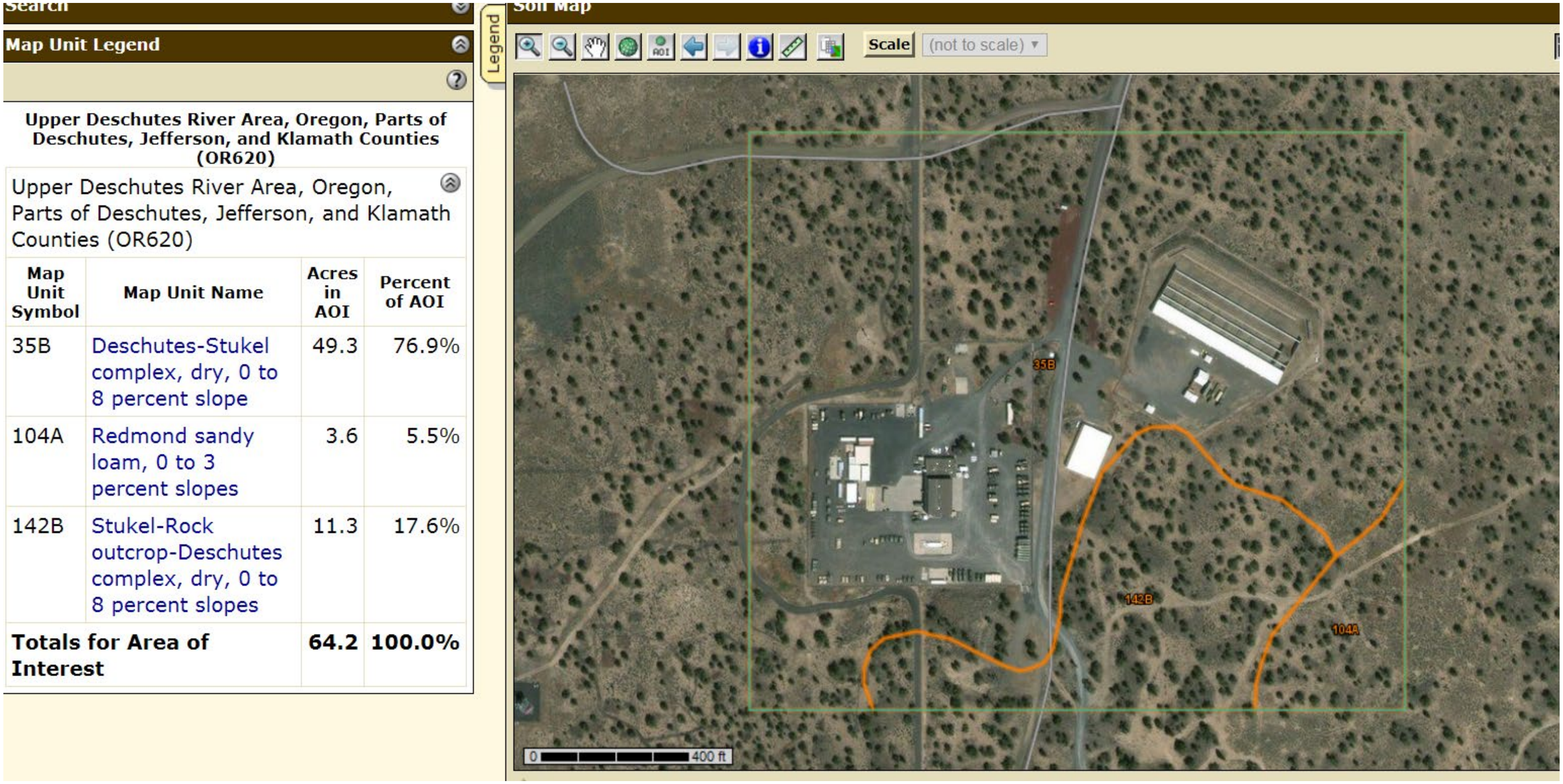
NAD 83 UTM Zone 10N
Projection: Transverse Mercator
2016 AGI KH

Imagery Source:
County Imagery through ESRI
Produced by USDA

The information on this map is for internal Guard planning purposes only. This map is a "Living document," in that it is intended to change as new data becomes available and is incorporated into the Enterprise GIS database

COUTES – Redmond, Oregon

USDSA Web Soil Survey



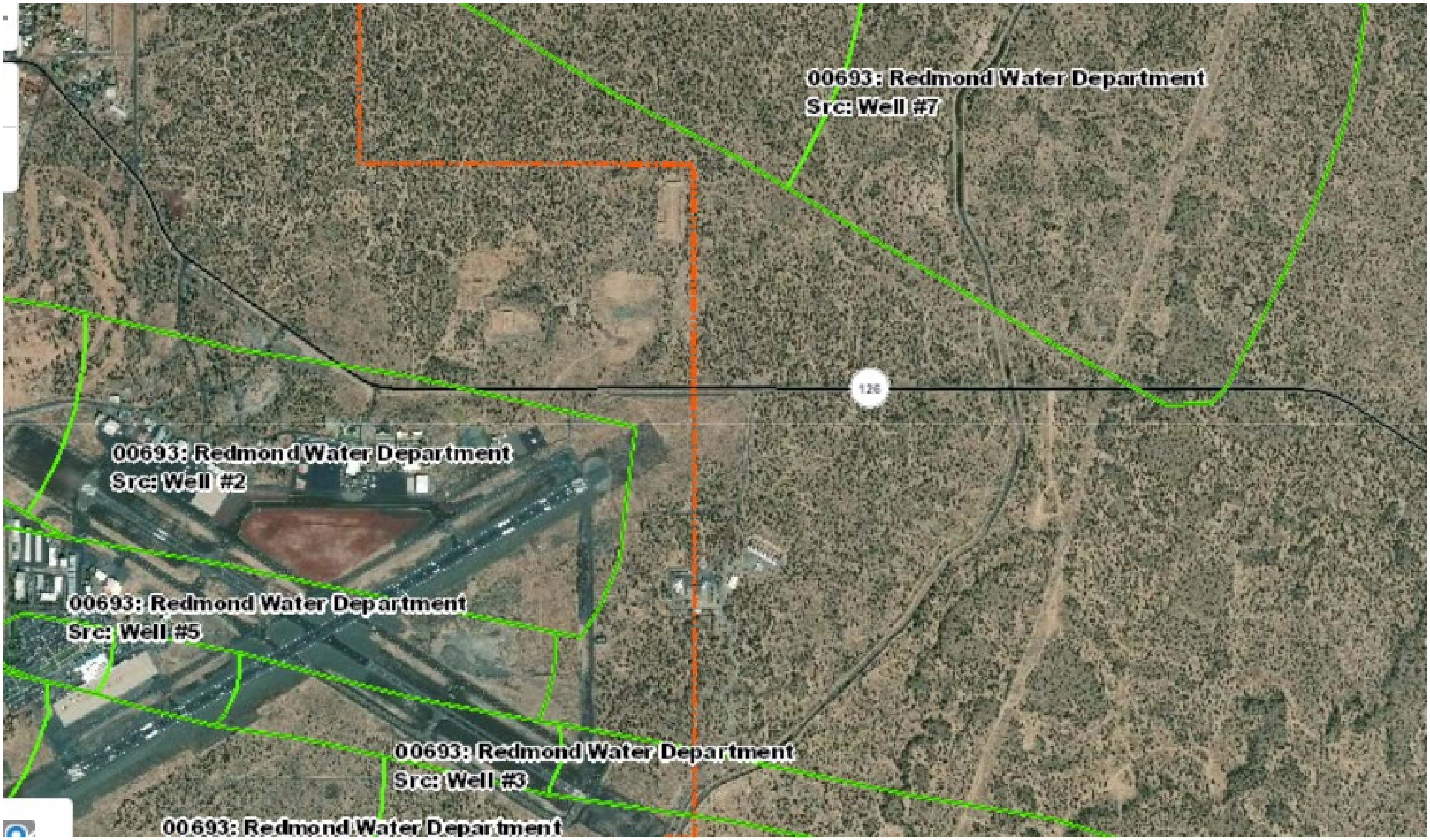
Upper Deschutes River Area, Oregon, Parts of Deschutes, Jefferson, and Klamath Counties (OR620)

Upper Deschutes River Area, Oregon, Parts of Deschutes, Jefferson, and Klamath Counties (OR620)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
35B	Deschutes-Stukel complex, dry, 0 to 8 percent slope	49.3	76.9%
104A	Redmond sandy loam, 0 to 3 percent slopes	3.6	5.5%
142B	Stukel-Rock outcrop-Deschutes complex, dry, 0 to 8 percent slopes	11.3	17.6%
Totals for Area of Interest		**64.2**	**100.0%**

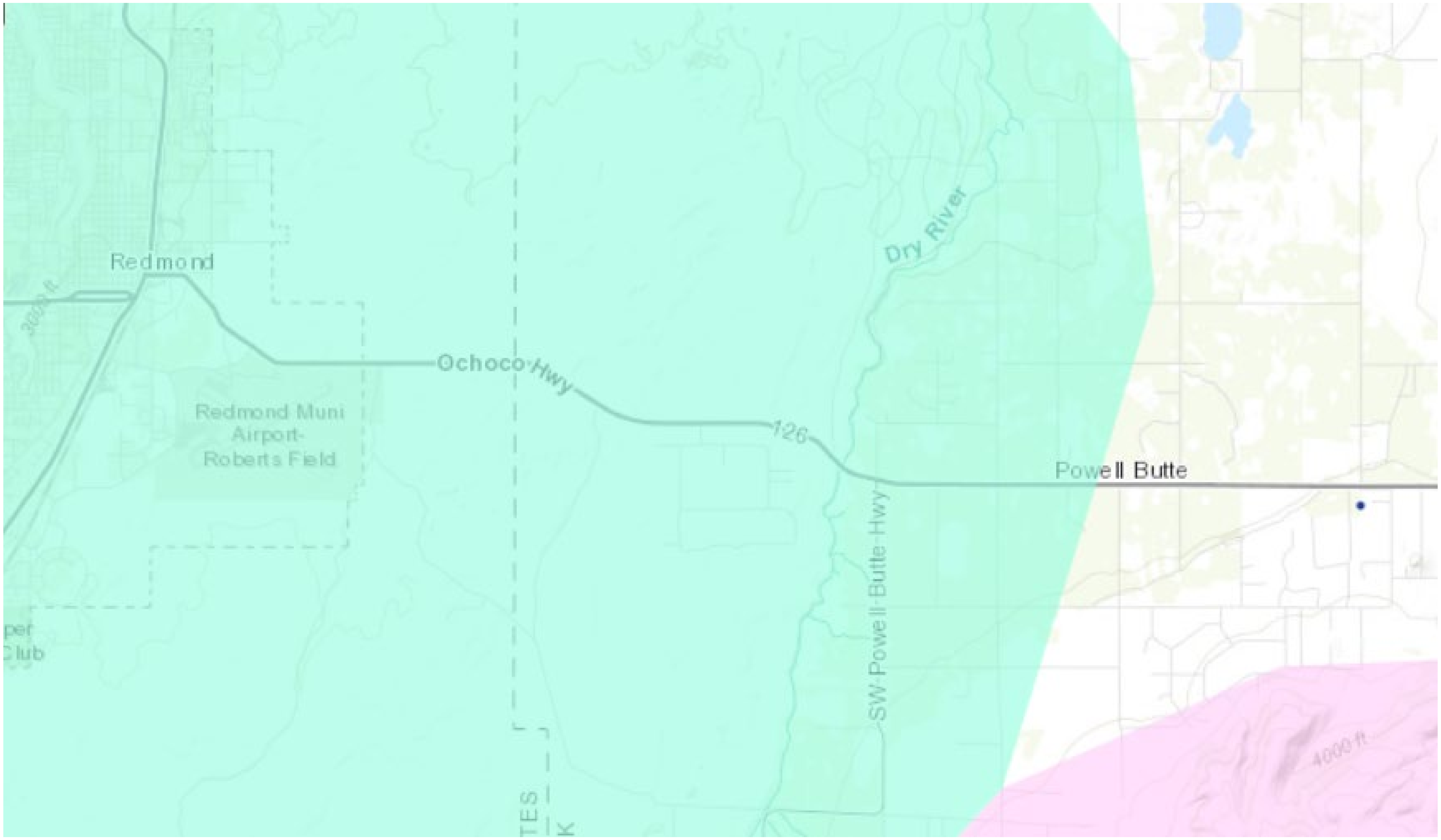
COUTES – Redmond, Oregon

Oregon DEQ Drinking Water Protection Program map



COUTES – Redmond, Oregon

USGS Monitoring Well Network



Appendix B
Preliminary Assessment Documentation

Appendix B.1
Interview Records

PA Interview Questionnaire - Environmental Manager

Facility: COUTES
Interviewer [redacted]
Date/Time: 10-5-18

Interviewee: [redacted]
Title: Environmental Mngr
Phone Number:
Email:

Can your name/role be used in the PA Report? Y or N
Can you recommend anyone we can interview?
[✓ Y] or N throughout notes

1. Roles or activities with the Facility/years working at the Facility.

oversees environmental management of OMD facilities since 2003

2. Where can I find previous facility ownership information?

Real Estate Manager, OMD

3. What can you tell us about the history of PFAS including aqueous film forming foam (AFFF) at the Facility? Was it used for any of the following activities, circle all that apply and indicate years of active use, if known? Identify these locations on a facility map.

Maintenance
Fire Training Areas
Firefighting (Active Fire)
Crash
Fire Suppression Systems (Hangers/Dining Facilities)
Fire Protection at Fueling Stations
Non-Technical/Recreational/ Pest Management
Metals Plating Facility
Waterproofing Uniforms (Laundry Facilities)
Other

None aware of

4. Fill out CSM Information worksheet with the Environmental Manager. ✓

5. Are any current buildings constructed with AFFF dispensing systems or fire suppression systems? What are the AFFF/suppression system test requirements? What is the frequency of testing the AFFF/suppression system? Do you have "As Built" drawings for the buildings?

None aware of

PA Interview Questionnaire - Environmental Manager

Facility:________________
Interviewer:________________
Date/Time:________________

6. Are fire suppression systems currently charged with AFFF or have they been retrofitted for use of high expansion foam? If retrofitted, when was that done?

N/a

7. How is AFFF procured? Do you have an inventory/procurement system that tracks use?

if then through manufacturer via federal purchasing

8. What type of AFFF has been/is being used (3%, 6%, Mil Spec Mil-F-24385, High Expansion)? Manufacturer (3M, Dupont, Ansul, National Foam, Angus, Chemguard, Buckeye, Fire Service Plus)?

unknown

9. Where is the AFFF stored? How is it stored (tanks, 55-gallon drums, 5-gallon buckets)? What size are the storage tanks? Is the AFFF stored as a mixed solution (3% or 6%) or concentrated material?

unknown

10. How many FTAs are/were on this facility and where are they? Locate on a map. How many FTAs are active and inactive? For inactive FTAs, when was the last time that fire training using AFFF was conducted at them?

None

PA Interview Questionnaire - Environmental Manager

Facility:_______________
Interviewer:_______________
Date/Time:_______________

11. When a release of AFFF occurs during a fire training exercise, now and in the past, how is the AFFF cleaned and disposed of? Were retention ponds built to store discharged AFFF? Was the AFFF trickled to the sanitary sewer or left in the pond to infiltrate?

N/a

12. Can you recall specific times when city, county, and/or state personnel came on-post for training? If so, please state which state/county agency or military entity? Do you have any records, including photographs to share with us?

unknown

13. Did military routinely or occasionally fire train off-post? List the units that you can recall used/trained at various areas.

unknown

14. Did individual units come with their own safety personnel, did they also bring their own AFFF? Was training with AFFF part of these exercises? How were emergencies handled under these circumstances?

N/a

15. Are there specific emergency response incident reports (i.e., aircraft or vehicle crash sites and fires)? If so, may we please copy these reports? Who (entity) was the responder?

No - no aircraft onsite

PA Interview Questionnaire - Environmental Manager

Facility:_______________
Interviewer:_______________
Date/Time:_______________

16. Do you have records of fuel spill logs? Was it common practice to wash away fuel spills with AFFF? Is/was AFFF used as a precaution in response to fuel releases or emergency runway landings to prevent fires?

unknown – no spills aware of

17. Was AFFF used for forest fires or fire management on-post/off-post? If so, please describe what happened and who was involved?

unknown

18. Are there mutual aid/use agreements between county, city, and local fire department? Please list, even if informal. If formalized, may we have a copy of the agreement?

unknown

19. Can you provide any other locations where AFFF has been stored, released, or used (i.e. hangars, buildings, fire stations, firefighting equipment testing and maintenance areas, emergency response sites, storm water/surface water, waste treatment plants, and AFFF ponds)?

no

20. Are you aware of any other creative uses of AFFF? If so, how was AFFF used? What entities were involved?

no

PA Interview Questionnaire - Environmental Manager

Facility:________________
Interviewer:________________
Date/Time:________________

21. Are there past studies you are aware of with environmental information on plants/animals/ groundwater/soil types, etc., such as Integrated Cultural Resources Management Plans or Integrated Natural Resources Management Plans?

inquire with cultural resources manager (CMD)

22. What other records might be helpful to us (environmental compliance, investigation records, admin record) and where can we find them?

Potential invoice orders for purchases
(Dan Cleveland to provide)

23. Do you have or did you have a chrome plating shop on base? What were/are the years of operation of that chrome plating shop?

No

24. Do you know whether the shop has/had a foam blanket mist suppression system or used a fume hood for emissions control? If foam blanket mist suppression was used, where was the foam stored, mixed, applied, etc.?

No

25. How is off-spec AFFF disposed (used for training, turned in, or given to a local Fire Station)? If applicable, do you know the name of the vendor that removes off-spec AFFF? Do you have copies of the manifest or B/L?

unknown
likely to local fire if any

PA Interview Questionnaire - Environmental Manager

Facility:________________
Interviewer:________________
Date/Time:________________

26. Do you recommend anyone else we can interview? If so, do you have contact information for them?

[redacted] (Wildland Fire Mngr)

[redacted] (COWTES Supervisor)

PA Interview Questionnaire – Fire Station

Facility: COUTES
Interviewer: [redacted]
Date/Time: 10-5-18

Interviewee: [redacted]
Title: Wildland Fire Manager
Phone Number:
Email:

Can your name/role be used in the PA Report? Y or N
Can you recommend anyone we can interview?
Y or N

1. Roles or activities with the Facility/years working at the Facility.

Wildland Fire Manager, 2 years w/ OMD

2. What can you tell us about the history of AFFF at the Facility? Was it used for any of the following activities, circle all that apply and indicate years of active use, if known? Identify these locations on a facility map.

Maintenance (e.g., ramp washing)
Fire Training Areas
Firefighting (Active Fire)
Crash
Fire Suppression Systems (Hangers/Dining Facilities)
Fire Protection at Fueling Stations
Non-Technical/Recreational/ Pest Management

No use

3. Are any current buildings constructed with AFFF dispensing systems or fire suppression systems? What are the AFFF/suppression system test requirements? What is the frequency of testing at the AFFF/suppression systems?

No

4. Are fire suppression systems currently charged with AFFF or have they been retrofitted for use of high expansion foam?

No

5. How is AFFF procured? Do you have an inventory/procurement system that tracks use?

If, then it would be purchased through OMD accounting.

PA Interview Questionnaire – Fire Station

Facility: COUTES
Interviewer:________________
Date/Time:________________

6. What type of AFFF has been/is being used (3%, 6%, Mil Spec Mil-F-24385, High Expansion)? Manufacturer (3M, Dupont, Ansul, National Foam, Angus, Chemguard, Buckeye, Fire Service Plus)?

None

7. Is AFFF formulated on base? If so, where is the solution mixed, contained, transferred, etc.?

No

8. Where is the AFFF stored? How is it stored (tanks, 55-gallon drums, 5-gallon buckets)? What size are the storage tanks? Is the AFFF stored as a mixed solution (3% or 6%) or concentrated material?

Not applicable

9. How is the AFFF transferred to emergency response vehicles, suppression systems, flightline extinguishers? Is/was there a specified area on the facility where vehicles are filled with AFFF and does this area have secondary containment in case of spills? How and where are vehicles storing AFFF cleaned/decontaminated?

Not applicable

10. Provide a list of vehicles that carried AFFF, now and in the past, and where are/were they located?

None

11. Any vehicles have a history of leaking AFFF? Do you/did you test the vehicles spray patterns to make sure equipment is working properly? How often are/were these spray tests performed and can you provide the locations of these tests, now and in the past?

No flushing of lines onsite

PA Interview Questionnaire – Fire Station

Facility: COUTES
Interviewer:
Date/Time:

12. How many FTAs are/were on this facility and where are they? Locate on a map. How many FTAs are active and inactive? For inactive FTAs, when was the last time that fire training using AFFF was conducted at them?

None

13. What types of fuels/flammables were used at the FTAs?

None

14. What was the frequency of AFFF use at each location? When a release of AFFF occurs during a fire training exercise, now and in the past, how is/was the AFFF cleaned and disposed of? Were retention ponds built to store discharged AFFF? Was the AFFF trickled to the sanitary sewer or left in the pond to infiltrate?

Not applicable

15. Are there mutual aid/use agreements between county, city, local fire department? Please list, even if informal. If formalized, may we have a copy of the agreement? Can you recall specific times when city, county, state personnel came on-post for training? If so, please state which state/county agency, military entity? Do you have any records, including photographs to share with us?

Yes - structural fires responded to by the City of Redmond

16. Did individual units come on-post with their own safety personnel, did they also bring their own AFFF? Was training with AFFF part of these exercises? How were emergencies handled under these circumstances?

No agencies with AFFF use onsite

PA Interview Questionnaire – Fire Station

Facility: COUTTS
Interviewer: ________________
Date/Time: ________________

17. Did military routinely or occasionally fire train off-post? List units that you can recall used/trained at various areas.

No

18. Are there specific emergency response incident reports (i.e., aircraft or vehicle crash sites and fires)? If so, may we please copy these reports? Who (entity) was the responder?

None
No crashes at/near site
No aircraft at site

19. Do you have records of fuel spill logs? Was it common practice to wash away fuel spills with AFFF? Is/was AFFF used as a precaution in response to fuel releases or emergency runway landings to prevent fires?

No logs of spills
No AFFF use
No runway onsite

20. Was AFFF used for forest fires or fire management on-post/off-post? If so, please describe what happened and who was involved?

No

21. Can you provide any other locations where AFFF has been stored, released, or used (i.e. hangars, buildings, fire stations, firefighting equipment testing and maintenance areas, emergency response sites, storm water/surface water, waste water treatment plants, and AFFF ponds)?

No other locations

PA Interview Questionnaire – Fire Station

Facility: COUTES
Interviewer:
Date/Time:

22. Are you aware of any other creative uses of AFFF? If so, how was AFFF used? What entities were involved?

None

23. How is off-spec AFFF disposed (used for training, turned in, or given to a local Fire Station)? If applicable, do you know the name of the vendor that removes off-spec AFFF? Do you have copies of the manifest or B/L?

If had onsite, it would be given back to manufacturer or local fire station

24. Do you recommend anyone else we can interview? If so, do you have contact information for them?

onsite facility manager
([redacted])

Fire trucks washed onsite at washbays generally during the summer.

Repairs of fire trucks conducted at camp Withycombe (Clackamas)

PA Interview Questionnaire - Other

Facility: COUTES
Interviewer: [redacted]
Date/Time: 10-5-18

Interviewee: [redacted]
Title: Maintenance
Phone Number: Supervisor
Email:

Can your name/role be used in the PA Report? Y or N

Can you recommend anyone we can interview?

Y or N

Roles or activities with the Facility/Years working at the Facility:

Supervisor of maintenance operations for 14 years (since 2004)

PFAS Use: Identify accidental/intentional release locations, time frame of release, frequency of releases, storage container size (maintenance, fire training, firefighting, buildings with suppression systems (as builts), fueling stations, crash sites, pest management, recreational, dining facilities, metals plating, or waterproofing). How are materials ordered/purchased/disposed/shared with others?

- No known use or storage of AFFF onsite
- No fire training onsite
- No aircraft onsite
- No fire suppression system onsite
- No fire truck repairs onsite - all taken to Camp Withycombe (in Clackamas, OR)
- Yes fire truck washing at the wash bay during summer

Known Uses

Use
Procurement
Disposition
Storage (Mixed)
Storage (Solution)
Inventory, Off-Spec
Containment
SOP on Filling
Leaking Vehicles
Nozzle and Suppression System Testing
Dining Facilities
Vehicle Washing
Ramp Washing
Fuel Spill Washing and Fueling Stations
Chrome Plating or Waterproofing

Appendix B.2
Visual Site Inspection Checklists

Visual Survey Inspection Log

Recorded by: [redacted]
ARNG Contact:
Date: 10-5-18

Source/Release Information

Site Name / Area Name / Unique ID: CoUTES (Biak Training Center)
Site / Area Acreage: 35.5
Historic Site Use (Brief Description): maintenance facility

Current Site Use (Brief Description):

1. Was AFFF used (or spilled) at the site/area? Y / [✓ N]
   1a. If yes, document how AFFF was used and usage time (e.g., fire fighting training 2001 to 2014):

2. Has usage been documented? Y / [✓ N]
   2a. If yes, keep a record (place electronic files on a disk):

3. What types of businesses are located near the site? **Industrial / [✓ Commercial] / Plating / Waterproofing / Residential**
   3a. Indicate what businesses are located near the site
   Redmond Airport adjacent west

4. Is this site located at an airport/flightline? Y / [✓ N]
   4a. If yes, provide a description of the airport/flightline tenants

Other Significant Site Features:

1. Does the facility have a fire suppression system? Y / [✓ N]
   1a. If yes, indicate which type of AFFF has been used:
   1b. If yes, describe maintenance schedule/leaks:
   1c. If yes, how often is the AFFF replaced:
   1d. If yes, does the facility have floor drains and where do they lead? Can we obtain an as built drawing?

Transport / Pathway Information

Migration Potential:

1. Does site/area drainage flow off installation? [✓ Y] / N
   1a. If so, note observation and location:

2. Is there channelized flow within the site/area? Y / [✓ N]
   2a. If so, please note observation and location:

3. Are ~~monitoring~~ or drinking water wells located near the site? Y / N
   3a. If so, please note the location:
   Redmond water Department west

4. Are surface water intakes located near the site? Y / [✓ N]
   4a. If so, please note the location:

Significant Topographical Features:

1. Has the infrastructure changed at the site/area? [✓ Y] / N
   1a. If so, please describe change (ex. Structures no longer exist):
   historical during development – see aerials

2. Is the site/area vegetated? [✓ Y] / N
   2a. If not vegetated, briefly describe the site/area composition:

3. Does the site or area exhibit evidence of erosion? Y / [✓ N]
   3a. If yes, describe the location and extent of the erosion:

4. Does the site/area exhibit any areas of ponding or standing water? Y / [✓ N]
   4a. If yes, describe the location and extent of the ponding:

Visual Survey Inspection Log

Receptor Information

1. Is access to the site restricted? Y / [✓ N]

1a. If so, please note to what extent:

2. Who can access the site? **[✓ Site Workers] / [✓ Construction Workers] / [✓ Trespassers] / Residential / Recreational Users / Ecological**

2a. Circle all that apply, note any not covered above:

3. Are residential areas located near the site? Y / [✓ N]

3a. If so, please note the location/distance:

4. Are any schools/day care centers located near the site? Y / [✓ N]

4a. If so, please note the location/distance/type:

5. Are any wetlands located near the site? Y / [✓ N]

5a. If so, please note the location/distance/type:

Additional Notes

Photographic Log

Photo ID/Name	Date & Location	Photograph Description
~~AOI001~~	~~1/1/2018~~	~~Building 500, on flightline, looking south, NE Corner Fire Suppression System~~

Appendix B.3
Conceptual Site Model Information

Preliminary Assessment – Conceptual Site Model Information

Site Name: COUTES (Biak Training Center)

Why has this location been identified as a site?

Potential (historical use of AFFF)

Are there any other activities nearby that could also impact this location?

Redmond ~~[illegible]~~ airport (west) potentially

Training Events

Have any training events with AFFF occurred at this site? NO

If so, how often?

How much material was used? Is it documented?

Identify Potential Pathways: Do we have enough information to fully understand over land surface water flow, groundwater flow, and geological formations on and around the facility? Any direct pathways to larger water bodies?

Surface Water:

Surface water flow direction? NW

Average rainfall? 8 ~~[illegible]~~ in/yr (1990-2018)

Any flooding during rainy season? No/unknown

Direct or indirect pathway to ditches?

Direct or indirect pathway to larger bodies of water? N/a

Does surface water pond any place on site? NO

Any impoundment areas or retention ponds? NO

Any NPDES location points near the site? wastewater discharge point west boundary

How does surface water drain on and around the flight line?

N/a no flight line

Preliminary Assessment – Conceptual Site Model Information

Groundwater:

Groundwater flow direction? NW

Depth to groundwater? 390 ft

Uses (agricultural, [✓ drinking water], irrigation)?

Any groundwater treatment systems? NO

Any groundwater monitoring well locations near the site? NO

Is groundwater used for drinking water? yes

Are there drinking water supply wells on installation? yes

Do they serve off-post populations? NO

Are there off-post drinking water wells downgradient yes

Waste Water Treatment Plant:

Has the installation ever had a WWTP, past or present? NO

If so, do we understand the process and which water is/was treated at the plant?

Do we understand the fate of sludge waste?

Is surface water from potential contaminated sites treated?

Equipment Rinse Water

1. Is firefighting equipment washed? Where does the rinse water go?

Fire trucks @ wash rack discharges to the west of installation after oil/water separation onsite

2. Are nozzles tested? How often are nozzles tested? Where are nozzles tested? Are nozzles cleaned after use? Where does the rinse water flow after cleaning nozzles?

NO

3. Other?

Preliminary Assessment – Conceptual Site Model Information

Identify Potential Receptors:

[✓ Site Worker] onsite

[✓ Construction Worker] onsite

Recreational User

[✓ Residential] offsite

[✓ Child] offsite

Ecological

Note what is located near by the site (e.g. daycare, schools, hospitals, churches, agricultural, livestock)?

Redmond Airport immediately west

Documentation

Ask for Engineering drawings (if applicable).

Has there been a reconstruction or changes to the drainage system? When did that occur?

Appendix C
Photographic Log

APPENDIX C – Photographic Log

Army National Guard, Preliminary Assessment for PFAS	Biak - Central Oregon Unit Training Equipment Site (COUTES)	Redmond, Oregon

Photograph No. 1

Description:

Expired dry chem, Purple-K, and carbon dioxide fire extinguishers (non-PFAS-containing) stored in cages at the exterior northwestern corner of the maintenance building.

Photograph No. 2

Description:

Expired Halon 1211 fire extinguisher (non-PFAS-containing) stored at the exterior northwestern corner of the maintenance building.

APPENDIX C – Photographic Log

Army National Guard, Preliminary Assessment for PFAS	**Biak - Central Oregon Unit Training Equipment Site (COUTES)**	**Redmond, Oregon**

Photograph No. 3

Description:

Active Class A-B-C fire extinguisher (non-PFAS-containing) secured to a military vehicle, staged in the parking lot of the facility.

Photograph No. 4

Description:

New dry chem and Purple-K fire extinguishers (non-PFAS-containing) stored in the warehouse building to the west of the maintenance building at the facility.

APPENDIX C – Photographic Log

Army National Guard, Preliminary Assessment for PFAS	Biak - Central Oregon Unit Training Equipment Site (COUTES)	Redmond, Oregon

Photograph No. 5

Description:

View of AOI 2: Wastewater Discharge Area. The area extends past the fence to the west, located along the central/western facility boundary, west of the warehouse building and wash rack bay. Note irrigation piping to the left, which is connected to the oil water separator (OWS) building and wash rack bay. View looking southwest.

Photograph No. 6

Description:

View of AOI 1: Wash Rack Bay. The wash rack bay is located along the eastern side of the wash rack/oil/water separator (OWS) building, west of the maintenance building in the central portion of the facility. The bay is paved and equipped with catch basins, which conveys wastewater via underground piping, discharging to the wastewater discharge area via irrigation to the west (AOI 2). View looking south.


[redacted] [redacted] [redacted]

APPENDIX C – Photographic Log

Army National Guard, Preliminary Assessment for PFAS	Biak - Central Oregon Unit Training Equipment Site (COUTES)	Redmond, Oregon

Photograph No. 7

Description:

Expired dry chem, Purple-K, and carbon dioxide fire extinguishers (non-PFAS-containing) stored in a cardboard box at the exterior northwestern corner of the maintenance building. View looking northwest.

Photograph No. 8

Description:

Expired dry chem, Purple-K, and carbon dioxide fire extinguishers (non-PFAS-containing) stored in cages in the warehousing building in the eastern portion of the facility (east of the maintenance building and south of the shooting range).