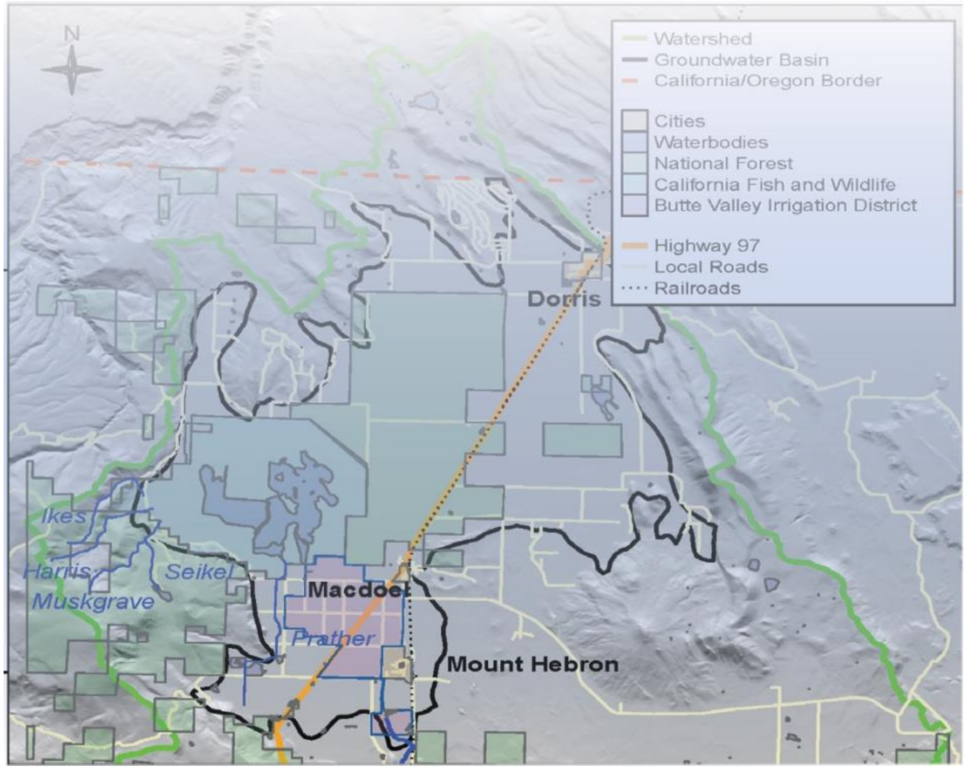
DECEMBER 2021

CHAPTER 2: PLAN AREA
AND BASIN SETTING

SISKIYOU COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT

Butte Valley Groundwater Sustainability Plan

FINAL DRAFT REPORT



SISKIYOU COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT GROUNDWATER SUSTAINABILITY AGENCY
BUTTE VALLEY GROUNDWATER SUSTAINABILITY PLAN (Public Draft)

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Contents

List of Acronyms

Abbreviation	Explanation
ug/L	Micrograms per liter
AF	Acre-feet
AFY	Acre-feet per year
amsl	above mean sea level
ASAR	Adjusted sodium absorption ratio
bgs	Below ground surface
BVID	Butte Valley Irrigation District
BVWA	Butte Valley Wildlife Area
CASGEM	California Statewide Groundwater Elevation Monitoring Program
CDFW	California Department of Fish and Wildlife
CDPH	California Department of Public Health
cfs	Cubic feet per second
CIWQS	California Integrated Water Quality System Project
CNRA	California Natural Resources Agency
CSEHD	County of Siskiyou Environmental Health Division
DAC	Disadvantaged community
DOI	U.S. Department of the Interior
DWR	California Department of Water Resources
ft	Foot/feet
FZ	Fault zone, an interconnected network of closely space earthquake faults.
gal	Gallon(s)
gpm	Gallons per minute
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
HCM	Hydrogeologic conceptual model
Holocene	A geologic time scale term, marking the time period between 11,500 years ago to the Present.
in	Inch/inches
km	Kilometer/kilometers
l/min	Liters per minute
m	Meter/meters
m3	Cubic meters

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Abbreviation	Explanation
m3/yr	Cubic meters per year
Ma	Million years ago
MCL	Maximum contaminant level
mg/L	Milligrams per liter
MHI	Median household income
mi	Mile/miles
ML	Local magnitude (Richter magnitude)
MW	Monitoring well
NCRWQCB	California North Coast Regional Water Quality Control Board
NOAA	United States National Oceanic and Atmospheric Administration
OSWCR	Online Systems for Well Completion Reports
Pleistocene	A geologic time scale term, marking the time period between 1.8 Ma and 11,500 years ago.
Pliocene	A geologic time scale term, marking the time period between 5.3 Ma and 1.8 Ma years ago.
PLSS	Public Land Survey System
ppb	Parts per billion
ppm	Parts per million
Quaternary	A geologic time scale term, marking the time period between 1.8 Ma to the Present.
SDAC	Severely disadvantaged community
sq	Square
SWRCB	California State Water Resources Control Board
TDS	Total dissolved solids
Tertiary	A geologic time scale term, marking the time period between 65.5 Ma to 1.8 Ma.
U.S.	United States
UL	Upper level
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USFS	United States Forest Service

Glossary

Term	Explanation
Adjudicated Areas	Where disputes over legal rights to groundwater have resulted in a court-issued ruling (known as an adjudication). Adjudications can cover an entire basin, a portion of a basin, or a group of basins.
Alluvial Fan	A gently sloping mass of sediment deposited by a stream that looks like an open fan when viewed from above. They often occur in arid or semiarid regions where a stream issues from a narrow canyon onto a plain or valley floor.
Alluvium	Clay, silt, sand, gravel, or other particulate material that have been deposited by a body of running water in a streambed, flood plain, delta, or at the base of a mountain.
Andesite	A fine-grained dark-colored ignous rock that has been erupted on the Earth’s surface, and is more viscous or ”sticky” compared to basalt. Cooled andesite lava flows typically consist of large, smooth-sided blocks up to several meters (~10 feet) in size. The edges of lava flow edges are steep and can be more than 100 m (300 ft) thick, consisting of piles of large angular blocks balancing precariously on one another.
Basalt	A dark-colored, fine-grained igneous rock that has been erupted on the Earth’s surface, that typically form thin, extensive lava sheets that can travel long distances. Basalt is the least viscous or most ”fluid” of the main lava types. It is considered the most primitive type of lava, with minimal alteration from the source mantle material beneath the tectonic plates.
Basin Prioritization	Classification of California’s 515 groundwater basins and subbasins into priorities based primarily on the importance of groundwater to the area. The priority of basins and subbasins determines the schedule for completing GSPs and whether SGMA provisions apply in a given basin. Critical, High, and medium, priority basins must comply with SGMA.
Best Management Practices (BMPs)	Practices designed to help achieve sustainable groundwater management. BMPs are intended to be effective, practical, and based on best available science.
Block Faulting	A type of normal faulting where large normal faults break the Earth’s crust into blocks as the region is pulled apart under extensional stress. Typically forms valleys, such as Death Valley in California.
Breccia	A coarse-grained rock of angular rock fragments that has been consolidated with mineral cement or fine-grained matrix.
Bulletin 118	A California Department of Water Resources (DWR) document outlining the locations and characteristics of groundwater basins in California.

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Term	Explanation
Confined Aquifer	A water bearing formation that is completely filled with groundwater and under pressure from overlying material that restricts movement of water.
Consolidated / Unconsolidated	Consolidation is any process where loose material becomes firm and coherent, such as cementation of sand into sandstone. Unconsolidated material is loose earth material such as volcanic ash or sand.
Critically Overdrafted	Basins and subbasins identified by DWR to be subject to conditions of critical overdraft. GSPs are due in 2020.
Dacite	A fine-grained light-colored ignous rock that has been erupted on the Earth’s surface, with a mineral composition that makes dacite lava flows sluggish and thick. Typically, dacite lava flows are so viscous and thick that they form a dome over the eruption center at the end of an explosive eruption cycle. Eruptions of dacite magmas can be explosive.
Dune Sand	Sand piled up by the wind into a sand dune.
Eocene	An epoch within the Tertiary period that began 55.8 million years ago (Ma) and ended 33.8 Ma.
Glaciation	The formation of glaciers, a large mass of ice formed on land that can cause extensive erosion of surrounding rock. When glaciers melt, they can leave behind moraines or mounds of rock debris (glacial till). The last major period of glaciation in the western US was 18,000 years ago.
Graben	An elongate portion of the crust bound by faults on the long sides and displaced downward, such as rift valleys. They form in conditions where the Earth’s crust is being pulled apart under extensional stress.
Groundwater Sustainability Agency (GSA)	One or more local agencies that implement the provisions of SGMA.
Groundwater Sustainability Plan (GSP)	A local plan proposed by a GSA and approved by the state.
Holocene	An epoch within the Quaternary that began 0.012 million years ago (Ma) and continues to the present.
Igneous	A rock that solidified from molten material such as lava or magma. One of the three major rock classes (igneous, sedimentary, metamorphic).
Measurable Objectives	Conditions linked to the sustainability goals of the GSP, to be achieved in the basin within 20 years.

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Term	Explanation
Metamorphic	A metamorphic rock formed from mineralogical, chemical, or structural changes of a pre-existing rock in response to changes in temperature, pressure or stress. This generally occurs if the rock has been moved deep into the Earth's crust, such as through long-term deposition of materials on top of the rock or faulting. One of the three major rock classes (igneous, sedimentary, metamorphic).
Miocene	An epoch within the Tertiary period that began 23 million years ago (Ma) and ended 5.3 Ma.
Normal Fault	A fracture in the Earth crust that forms when a region is under extensional stress (the region is being pulled apart). The fault dip is usually 45 to 90 degrees. Typically, one block or side of the fault is moving down relative to the other side.
Phytogenic Dune	Phytogenic dunes are common in modern day playas and form when wind-deposited silt and fine sand are trapped by scrub plants.
Playa	A playa is a dry, vegetation-free, flat area at the lowest part of an undrained desert basin.
Pleistocene	An epoch within the Quaternary that began 1.8 million years ago (Ma) and ended 0.012 Ma.
Pliocene	An epoch within the Tertiary period that began 5.3 million years ago (Ma) and ended 1.8 Ma.
Potentiometric Surface	The total head of groundwater, defined as the level at which groundwater would rise in a well. The water table is a type of potentiometric surface.
Pyroclastic Deposit/Rock	Pyroclastic rocks are composed of rock fragments from an explosive volcanic eruption or aerial expulsion from a volcanic vent, and may include ash, lapilli, bombs, blocks, and shattered country rock.
Quaternary	A period that starts after the end of the Tertiary that began 1.8 millions years ago (Ma) and continues in the present. Epochs or sub-periods within the Quaternary, from the oldest to most recent, includes the Pleistocene and Holocene.
Rhyolite (Tuff)	A light-colored ignous rock that has been erupted on the Earth's surface, with a mineral composition that typically erupts explosively and fragments into small pieces (pyroclasts). Consolidated rhyolite pyroclasts is called a rhyolite tuff. Rhyolite is typically pale colored and often light grey, tan, or pink.
Sedimentary	A sedimentary rock formed from the consolidation of sediment, such as sand (sandstone) or organic material (coal). One of the three major rock classes (igneous, sedimentary, metamorphic).
Sustainability Goals	Metrics established in the GSP planning process to ensure that a basin is operated within its sustainable yield.

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Term	Explanation
Sustainable Yield	The amount of water that can be extracted from a basin without causing problems to the groundwater basin.
Talus	A heap or mass of rock fragments lying at the base of a cliff or very steep, rocky slope, and formed by gravitational falling, rolling, or sliding.
Tertiary	A period in the geologic time scale that began 65.5 million years ago (Ma) and ended 1.8 Ma. The Tertiary includes several sub-periods or epochs, from the oldest to most recent: Paleocene, Eocene, Oligocene, Miocene, and Pliocene. The next period after the end of the Tertiary is the Quaternary.
Tuff	A rock of consolidated pyroclastic (fragmented rock erupted explosively) material.
Unconfined Aquifer	A water bearing formation partially filled with groundwater where the upper groundwater surface is free to fluctuate under atmospheric pressure.
Unconformity	A break in the geologic record, typically by erosion. Commonly recognized by a sudden jump or large gap in rock ages between deep older rocks and shallow young rocks.
Undesirable Results	The problems that SGMA strives to solve or prevent.
Volcanic Ash	Fine pyroclastic material (material ejected from a volcanic eruption) smaller than 2 mm in diameter. The term usually refers to unconsolidated material. Consolidated volcanic ash is called a tuff.
Water Budget	An estimated accounting of all the water (surface and groundwater) that flows into and out of a basin.

Glossary references include King (1994); USGS (2009b); USGS (2009a); USGS (n.d.d); USGS (n.d.a); USGS (n.d.c); USGS (n.d.b); Bates and Jackson (1984); Francis and Oppenheimer (2004); USGS (2007); USGS (n.d.e).

Chapter 2 - Plan Area and Basin Setting

2.1 Description of the Plan Area

2.1.1 Summary of Jurisdictional Areas and Other Features

The Butte Valley Groundwater Basin (Basin) is a 79,700 acre (125 square mile (sq mi); 326 square kilometer (sq km)) subbasin within the upper Klamath Groundwater Basin that extends between California and Oregon (Wood 1960; Gannett, Wagner, and Lite Jr. 2012). The Butte Valley watershed (Watershed) is roughly three times larger than the Basin and contains two other DWR recognized groundwater basins. The Watershed is the drainage area that recharges surface water in the Basin, shown in Figure 1.1. The Watershed is located immediately northeast of Mount Shasta, whose flank can be seen in the bottom left corner of Figure 1.1.

The predominately agricultural Basin is in northern Siskiyou County, California, just south of the Oregon border (see Figure 1.1). Under the 2019 basin prioritization conducted by the California Department of Water Resources (DWR), the Butte Valley Groundwater Basin (DWR Basin 1-003) is designated as medium priority (DWR 2019d). The Basin sits on the western edge of the Modoc Plateau, a broad and rugged volcanic upland with land surface elevations generally between 4,500 to 5,000 feet (ft) (1371-1524 meters (m)) above mean sea level (amsl) (Gannett, Wagner, and Lite Jr. 2012). The Basin is located at an elevation of about 4,200 ft (1280 m) amsl and is topographically closed and bounded by topographic highs in all directions: the Cascade Mountains in the north, south and west, the Mahogany Mountain ridge in the east and Sheep Mountain and Red Rock Valley in the southeast (DOI 1980; DWR 2004). The Basin contains Meiss Lake, the remnant of a prehistoric lake that once filled Butte Valley, and several streams that all flow into the Basin from the surrounding Watershed, as shown in Figure 1.1 (King 1994). Butte Creek is the largest stream flowing into Butte Valley.

2.1.1.1 Jurisdictional Areas and Land Use

The Siskiyou County Flood and Water Conservation District serves as the Groundwater Sustainability Agency (GSA) for the Basin. The Basin has three notable population centers: the City of Dorris (Population: 962), Macdoel (Population: 155), and Mount Hebron (Population: 81) (DWR 2016b). Due to their small populations, Macdoel and Mount Hebron are described as census-designated places by the United States (U.S.) Census Bureau. U.S. Highway 97 crosses the Basin from the southwest to northeast, passing through Dorris and Macdoel. The Union Pacific Railroad passes through Butte Valley from north to south, passing through all three cities. The railroad generally follows U.S. Highway 97 between Macdoel and Dorris and leaves the Valley north of Dorris via a train tunnel through the Mahogany Mountain ridge. South of Mount Hebron, the railroad generally follows the path of Butte Creek (Figure 1.1). The Basin and watershed do not contain any tribal lands or tribal interests.

Disadvantaged Communities

There are three severely disadvantaged communities (SDACs) in the Basin that suffer from a combination of economic, health, and environmental burdens (Figure 1.3). By definition, disadvantaged communities (DACs) have a median household income (MHI) less than 80% of the statewide MHI while SDACs are below 60%. All three of the communities in the Basin are categorized as SDACs: Dorris has a MHI of $28,963, Macdoel has a MHI of $35,294, and Mount Hebron has a MHI of $28,170 (DWR 2016b). All SDAC communities rely on groundwater as their sole source of drinking water, using a combination of municipal water district, small water suppliers, and domestic wells.

Water Suppliers

The Basin has no adjudicated areas and contains one irrigation district, one water district, and four small water suppliers (Figure 1.2). The Butte Valley Irrigation District (BVID) is a private water supplier that manages irrigation water for roughly 5,000 acres (20 sq km) of land northwest of Mount Hebron. It manages the largest groundwater distribution and management network in the Basin and distributes water throughout the service area through a network of pipes. Farms serviced by the irrigation district are allocated 2 acre-feet per acre per year (AFY) (0.6 m/yr)). BVID supplies water from approximately 20 wells out of its 25 well network. The City of Dorris has a small municipal water district serving approximately 938 residents (McKay 2019). It has 2 wells in its supply network. However, one well is only used as an emergency supply (McKay 2019). Groundwater supplies 100% of the district water supply (McKay 2019).

In the region surrounding Macdoel and Mount Hebron, four small water suppliers report to the California Department of Public Health (CDPH) (SWRCB 2019a). Macdoel Waterworks operates in the middle of Macdoel and serves a population of 20 with two monitoring wells (SWRCB 2019a). Juniper Village Farm Labor Housing is located southeast of Macdoel and has one groundwater well serving a population of 200 (SWRCB 2019a; SWRCB 2019b). The Mt. Hebron Work Center is operated by the U.S. Forest Service (USFS) and operates in the middle of Mount Hebron with one groundwater well serving a population of 30 (SWRCB 2019a; SWRCB 2019b). The USFS Goosenest District Office operates west of Mount Hebron alongside U.S. Highway 97. It has one groundwater well serving a population of 30 (SWRCB 2019a; SWRCB 2019b).

Federal Managed Lands

Over 40% of the Basin is covered by federal and state managed lands, as shown in Figure 1.2. Federally managed land consists of the Klamath National Forest, including the Butte Valley National Grassland and small sections of the National Forest along the Basin border. The Butte Valley National Grassland is primarily north of U.S. Highway 97, covering 18,400 acres (74 sq km) or 23% of the total Basin surface area. Butte Valley Grassland became the nation's 20th National Grassland in 1991 after strong support from the local Congressional delegation, California Cattlemen's

Association, California Department of Fish and Wildlife (CDFW; formerly California Department of Fish and Game), and the local public.

After serving as a military practice bombing range in the 1940s, the federal government and Natural Resources Conservation Service (formerly Soil Conservation Service) re-stabilized the soil by planting over 4,000 acres (16 sq km) of crested wheatgrass. They worked with local ranchers to set up grazing associations and developed local conservation practices, which continue to the present day. Today, the National Grassland is shrub-steppe, with sagebrush, rabbitbrush, bitterbrush, basin wildrye, intermediate wheatgrass, and other arid grasses and flowers with scattered western juniper trees. Grazing cattle reside within the National Grassland alongside local wildlife including mule deer, Roosevelt elk, pronghorn, coyote, marmot, weasel, porcupine and bobcat. Resident bird species include Swainson's Hawk, golden eagle, bald eagle, merlin, sandhill crane, great horned owls, short-eared owls, and long-eared owls, with winter visitors including red-tailed hawk, Ferruginous Hawk, rough-legged hawk, northern harrier, American Kestrel, and prairie falcon (USFS website).

During World War II the US Navy used 7,040 acres (28 sq km) of land to develop the Siskiyou Rocket and Bombing Range, an aerial gunnery range used in winter when other stations were inhibited by poor weather conditions. By May 1945, the U.S. Navy gained use of the area for air-to-ground firing, high and low level bombing and strafing. Sub-Caliber Aerial Rockets were used at the site. The area covered parts of the Butte Valley National Grassland and Butte Valley Wildlife Area. The U.S. Department of Defense (DOD) has conducted site inspection and monitored the site for discarded military munitions and explosives, including unexploded ordinance. In 1984, a wildlife survey discovered a rocket that was removed by the DOD, though only inert practice rockets were used at the site. Qualitative site reconnaissance and soil sampling found that metal pollution does not exceed human health screening values. The Department of Toxic Substances Control is the oversight and cleanup agency for the site, but no further action is planned as of September 2013. The cleanup site floods in the winter and is populated with grazing cattle the rest of the year (DTSC (2020)).

State Managed Lands

The state owns 13,500 (55 sq km) acres within the Basin, or 17% of the total Basin surface area, which includes the Butte Valley Wildlife Area (BVWA) and a small property at Mud Lake, as shown in Figure 1.2. The BVWA is approximately 13,400 acres (54 sq km) and contains wetlands, sage flats, farmlands, and the 4,000 acre (16 sq km) Meiss Lake. "BVWA is 13,200 acres (53.4 sq km) with 4,400 acres (17.8 sq km) of intensively managed wetlands, 4,000 acres (16.2 sq km) of Meiss Lake, and 4,800 acres (19.4 sq km) of habitat (NCRWQCB 2008)." It is bordered by the federal Klamath National Forest on the east and southwest. The Fish and Game Commission designated the site as a wildlife area in 1981 and it is currently managed by CDFW. Over 200 species of birds can be spotted in the Wildlife Area. Recreational activities include camping, hiking, wildlife viewing, and hunting. Hunting options include waterfowl, coots, moorhens, snipe, and doves. Four grain fields lie on the west and south side of the Wildlife Area. The small property at Mud Lake is owned but not managed by the state.

Land Use

Historical land use maps for Butte Valley are not available before 1996. Even without detailed historical land use surveys, there are enough historical records to form an image of changing land use over time. Irrigated land in Butte Valley has increased from approximately 12,000 acres (4,850

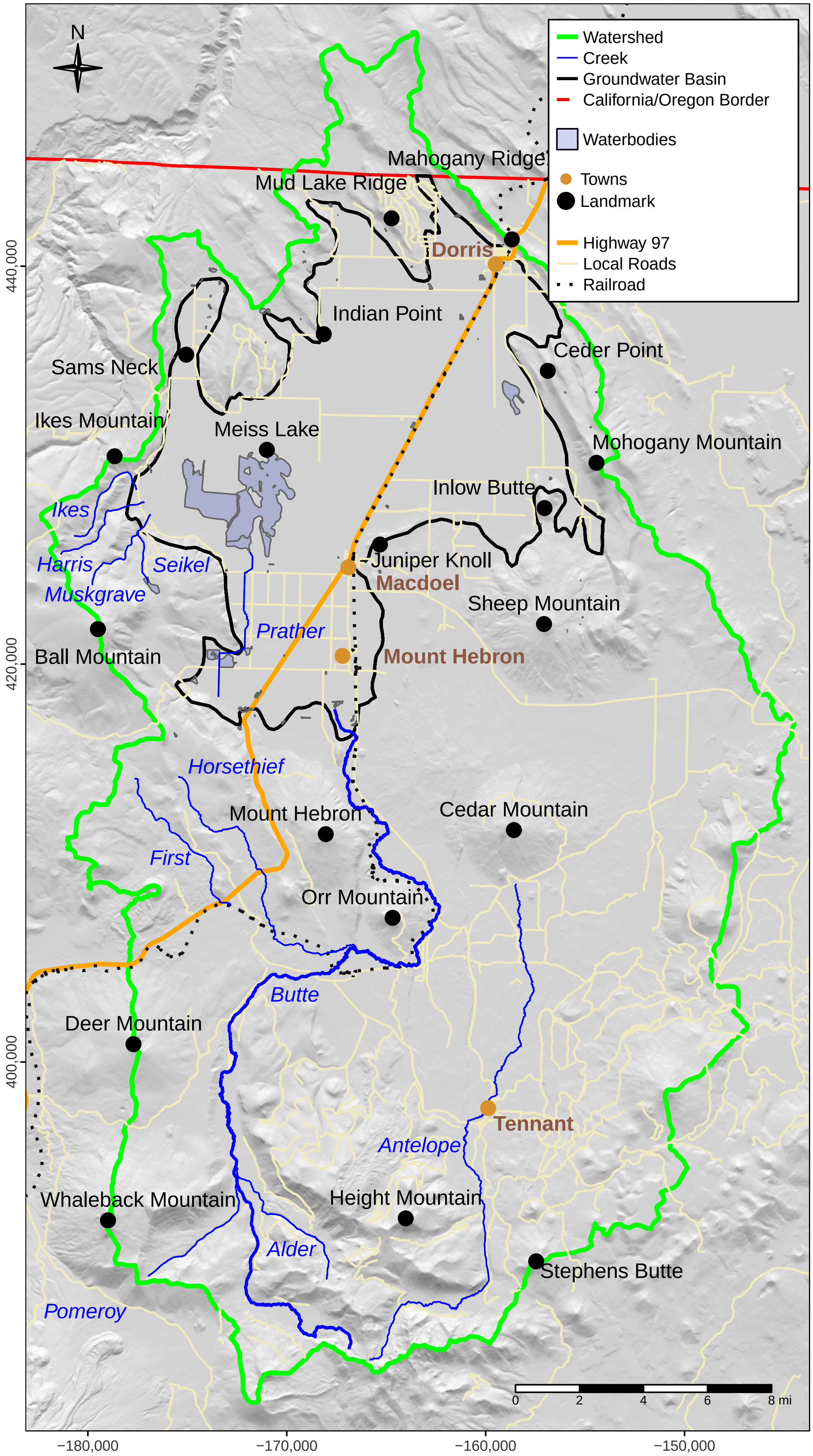


Figure 1.1: Butte Valley Watershed and Groundwater Basin Boundary

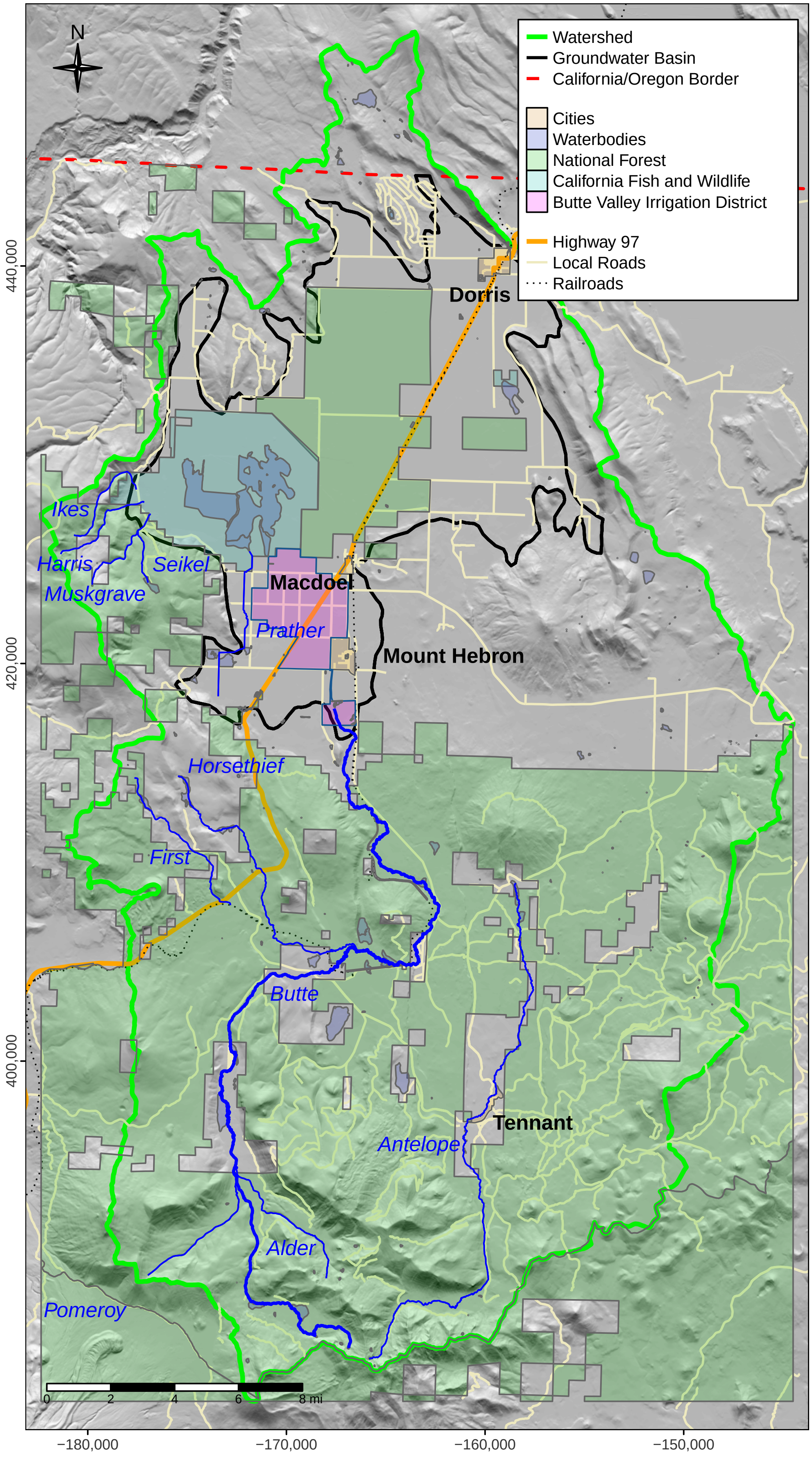


Figure 1.2: Butte Valley Watershed Jurisdictional Authorities.

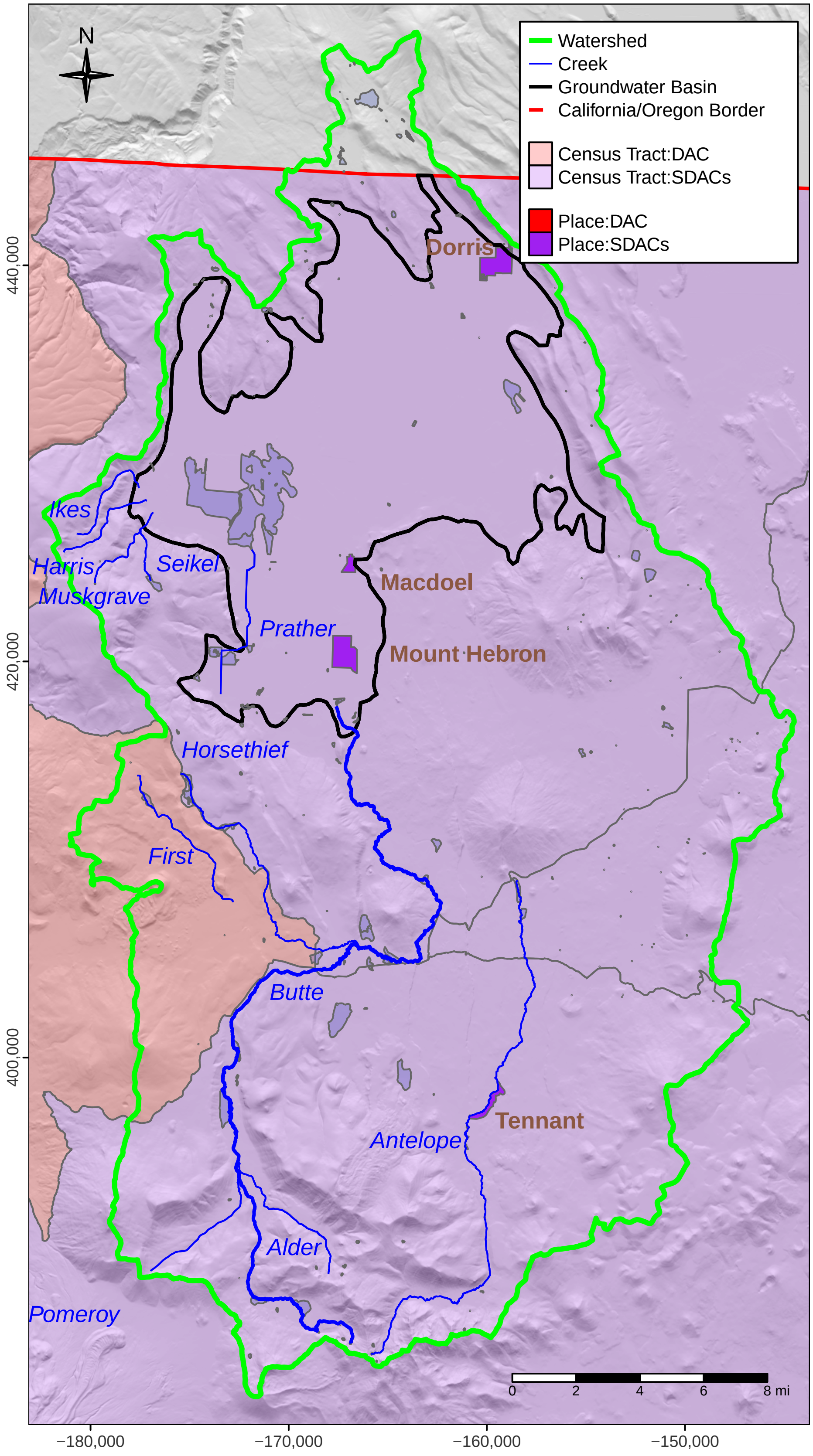


Figure 1.3: Based on the 2016 U.S. Census, place and track boundaries of Disadvantaged Communities (DACs: $42,737 <= MHI < $56,982) and Severely Disadvantaged Communities (SDACs: MHI < $42,737) in the Butte Valley watershed, using data from the Department of Water Resources DAC Mapping Tool (https://gis.water.ca.gov/app/dacs/).

Table 1.1: Acreage and percent of total Basin area covered by all identified land uses in the 2010 DWR land use survey.

Land Use Description	Acres	Percent of Basin Area
Alfalfa pasture	16,081	20.2
Grain and Hay	8,110	10.2
Urban Vacant	7,242	9.1
Riparian Vegetation	4,543	5.7
Idle	4,192	5.3
Truck and Nursery and Berry Crops	3,633	4.6
Pasture	2,341	2.9
Urban Residential	819	1.0
Semiagricultural and Incidental to Agriculture	655	0.8
Water Surface	398	0.5
Urban Industrial	292	0.4
Urban Commercial	51	0.1
Barren and Wasteland	1	0.0
Urban Landscape	17	0.0

hectares) in 1952 to over 37,000 acres (15,000 hectares) in 2010 as shown in Figure 1.5 (County of Siskiyou 1996; DWR 2010). Early records for Butte Valley do not track irrigated land by water supply or crop type, but between 2000 and 2010 the fraction of land irrigated by groundwater also increased as shown in Figure 1.5 (DWR 2000, 2010).

Butte Valley's economy is dominated by agriculture. The 2010 County land use survey assessed 60.8% of the Basin area and identified the following land use percent coverage: agriculture (38.7%), idle land (5.3%), and urban (10.6%). As of 2010 the major crops in Butte Valley were alfalfa, hay, and strawberry, which occupied approximately 18,400 acres, 8,000 acres, and 3,300 acres (7,450 hectares, 3,240 hectares, 1,300 hectares) respectively (DWR 2010). Butte Valley National Grassland is not included in the land use survey, but a number of local ranchers have permits to graze cattle (USFS 2020). Acreages associated with various land uses surveyed by DWR in 2010 are shown spatially in Figure 1.4, and numerically in Tables 1.1 (DWR 2010).

Strawberry is a significant economic commodity in Butte Valley. Recent market prices are $50,000 per acre of strawberries compared to $1,040 per acre of alfalfa (in 2016) and $822 per acre of hay (in 2016) [Smith (2016); Nelson 2021]. Butte Valley produces approximately 500 million plants annually (Nelson 2021). Strawberries in California grow on approximately 39,000 acres (USDA 2020a) and approximately 3,000 of those acres are from nursery production in Butte Valley [Nelson 2021 July 2021 TAC].

Butte Valley crops have several different growing cycles. Alfalfa is grown for four to six years before ripping soil and reseeding [TAC Meeting July 2021]. In contrast, hay, idle/fallow, and strawberry rotate in three annual cycles with strawberries replanted in the same field every three years (Nelson et al. 2019). Each year that a field is part of the strawberry rotation it is either used for hay, idle, or strawberry. In 2010 approximately 9,900 acres (4,000 hectares) were part of that rotation. Strawberry is only grown from March to September and receives irrigation throughout (Nelson et al. 2019). A small amount of garlic, occupying less than 400 acres, is also grown from September to August with irrigation throughout the winter if precipitation is insufficient.

Strawberry is grown and harvested in Butte Valley for daughter plant production. Mother plants are

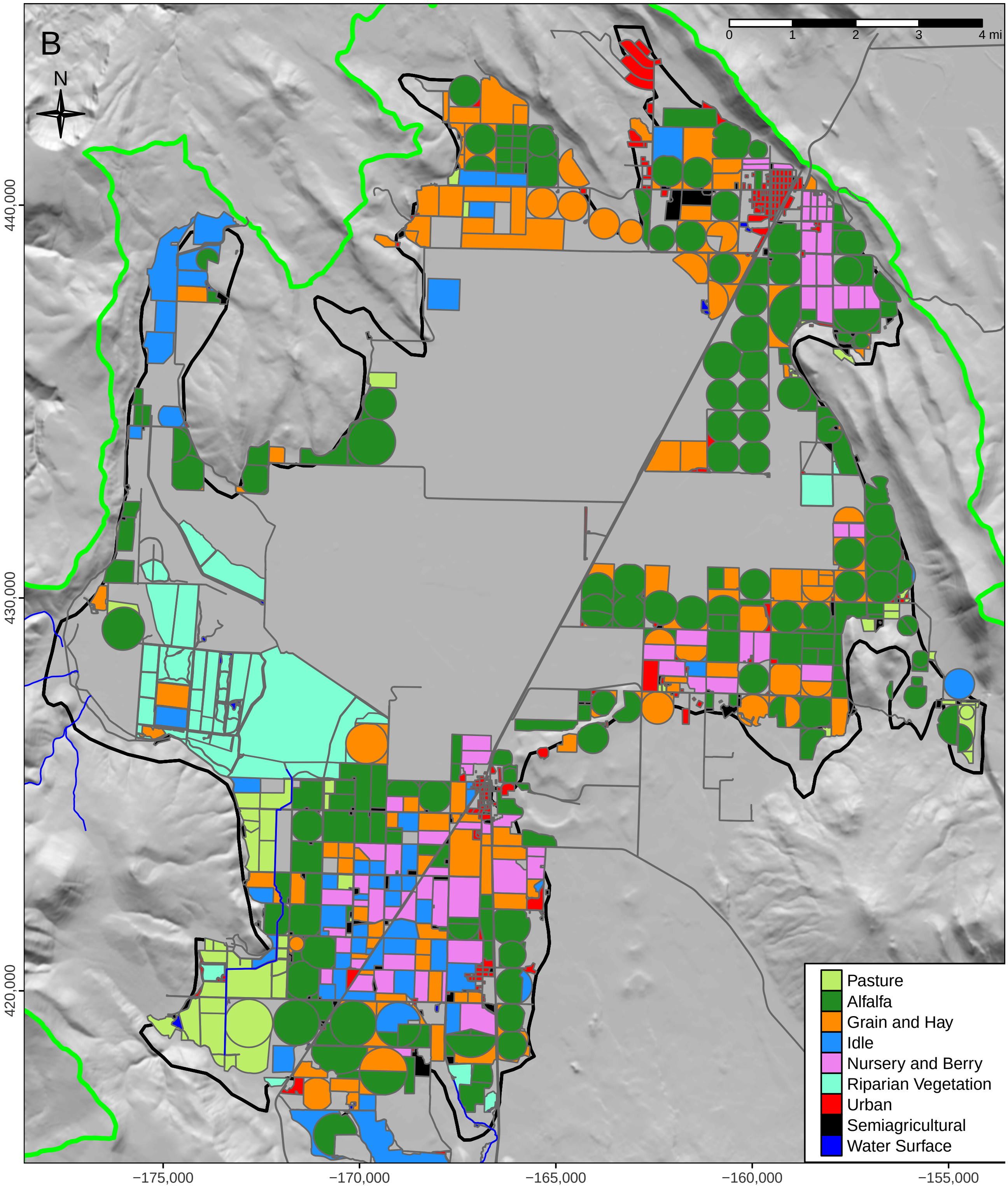


Figure 1.4: Land uses within the Butte Valley Groundwater Basin boundary taken from the DWR 2010 Land Use Survey.

started under protective coverings where they are grown for approximately twelve weeks under 22-inch tall micro-tunnels of flat fabric slightly above crops (Nelson et al. 2019). After twelve weeks the micro-tunnels are removed and the plants are allowed to produce stolons, commonly called runners, which produce daughter plants (Nelson et al. 2019). Eventually the daughter plants produce roots and form independent cloned plants from the mother plant. The harvested product grown in Butte Valley are live plants for transplant. Daughter plants are then transplanted to other regions where they produce fruit. In mid to late September the field is harvested for strawberry plants which are later transported to other parts of the United States for eventual berry production (Nelson et al. 2019).

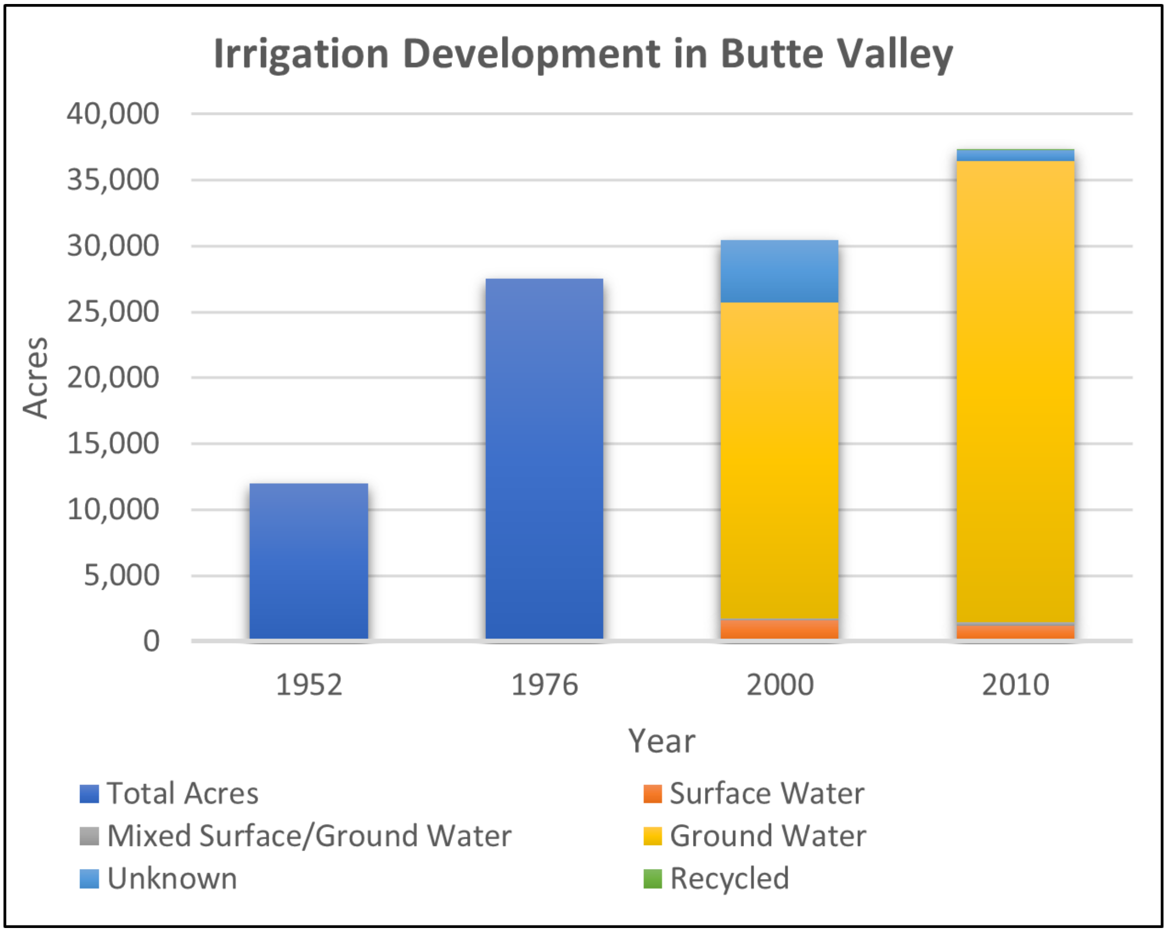


Figure 1.5: Change in Irrigated Acreage in Butte Valley, Siskiyou County, California (California Department of Water Resources, 2000, 2010; Siskiyou County, 1996; Rice, In Progress). Sale price per ton and tons harvested per acre both vary per year.

2.1.1.2 Well Records

Public data regarding wells are limited in Butte Valley. Using data from the DWR Online System for Well Completion Reports [OSWCR; DWR (2019a)], it is possible to visualize the approximate distribution (i.e., well density) of domestic, agricultural production, and public drinking water wells in the Basin, aggregated to each Public Land Survey System (PLSS) section (Figure 1.6). Because OSWCR represents an index of Well Completion Report records dating back many decades, this dataset may include abandoned or destroyed wells, or quality control issues such as inaccurate, missing, or duplicate records, but is nevertheless a valuable resource for planning efforts. BVID is the source of additional well records.

The primary uses of the wells reviewed were:

- Domestic Wells: 368
- Agricultural Production Wells: 294
- Public/Municipal Wells: 11

Of these 673 wells, all were assessed to be in or near Butte Valley, and all wells were geolocated with the specificity necessary to include them in the Butte Valley geologic model. A database of these wells was created to facilitate model development.

The density of groundwater wells is highest in the south and east sections of the Basin, especially near the cities of Dorris, Macdoel, and Mount Hebron, following the extent of agricultural land use, as shown in Figure 1.6 and discussed further in Section 2.1.3.3. The density of wells per square mile is shown in Figure 1.6.

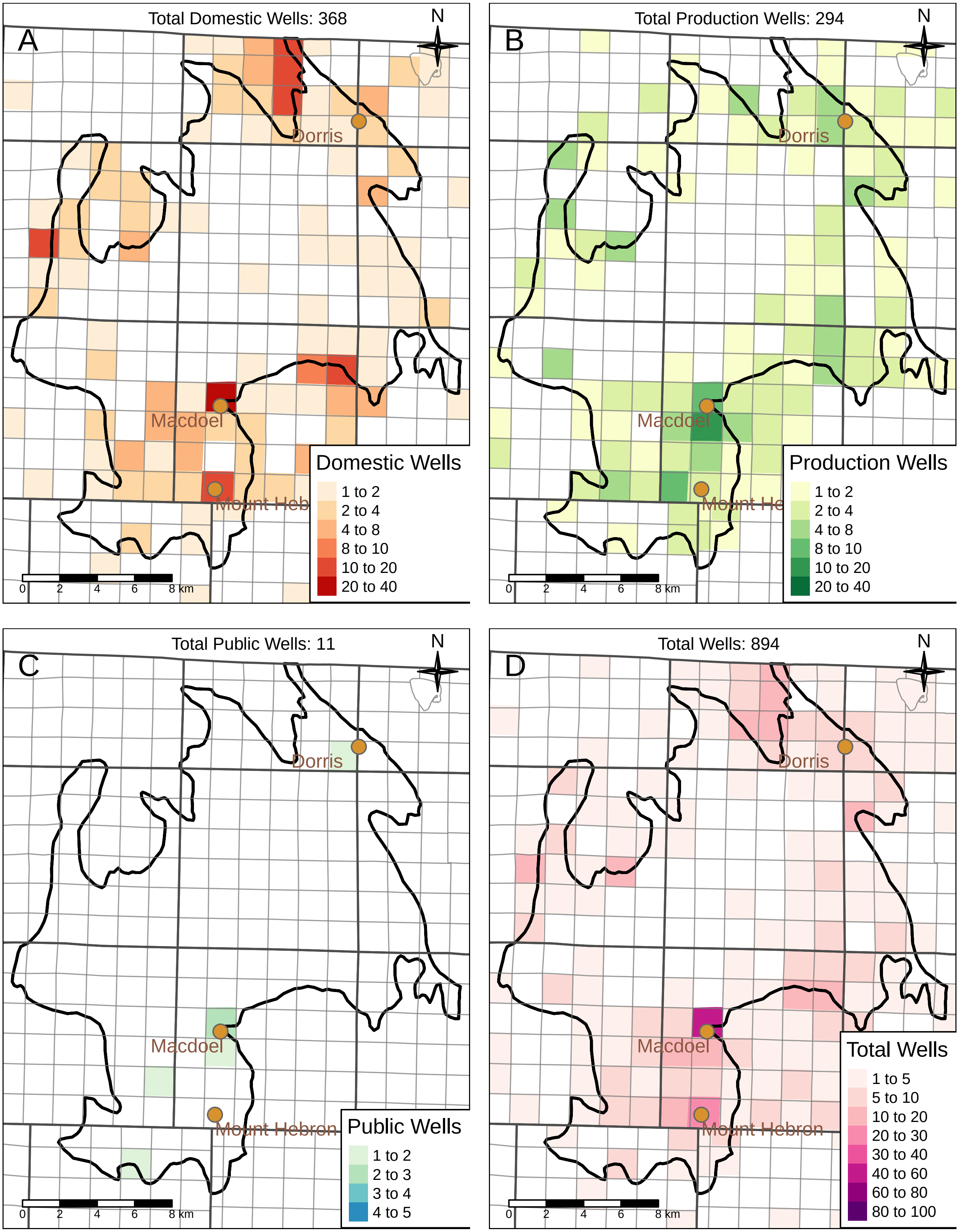


Figure 1.6: Choropleth maps indicating number of domestic (panel A), agricultural production (panel B), and public (panel C) Well Completion Reports present in each Public Land Survey System (PLSS) section, based on data from the DWR Online System for Well Completion Reports (OSWCR). Panel D shows the sum of panels A-C. PLSS sections delineated on maps are nominally one square mile.

2.1.2 Water Resources Monitoring and Management Programs

There is historical and ongoing work in the Basin related to monitoring and the management of surface water and groundwater resources. The following section describes each monitoring and/or management program and outlines the current understanding of (a) how these programs will be incorporated into GSP implementation and (b) how they may limit operational flexibility in GSP implementation. At this time Butte Valley does not have established conjunctive use programs for surface and groundwater allocation.

The programs described include:

- Water Quality Control Plan for the North Coast Region (Basin Plan)
- California Statewide Groundwater Elevation Monitoring Program (CASGEM)
- Butte Valley Irrigation District (BVID)
- City of Dorris Municipal Water District
- United States National Forest Service (USFS)
- California Department to Fish and Wildlife (CDFW)
- United States Bureau of Reclamation (USBR)
- Butte Valley Sustainability Agency
- Endangered Species Conservation Laws
  - Federal Endangered Species Act (ESA)
  - California Endangered Species Act (CESA)

2.1.2.1 Water Quality Control Plan for the North Coast Region

Groundwater within Butte Valley is regulated by the North Coast Regional Water Quality Control Board's (NCRWQCB or Regional Water Board) *Water Quality Control Plan for the North Coast Region* (Basin Plan) (NCRWQCB 2018). Groundwater is defined in the Basin Plan as:

> *Groundwater is defined as subsurface water in soils and geologic formations that are fully saturated all or part of the year. Groundwater is any subsurface body of water which is beneficially used or usable; and includes perched water if such water is used or usable or is hydraulically continuous with used or usable water.*

The Basin Plan includes water quality objectives for groundwater based on the assigned beneficial uses (NCRWQCB 2018). Table 2-1 in the Basin Plan designates all groundwaters with the following beneficial uses:

- Municipal and Domestic Supply (MUN)
- Agricultural Supply (AGR)
- Industrial Service Supply (IND)
- Native American Culture (CUL).

Potential beneficial uses designated for groundwater include: Industrial Process Supply (PRO) and Aquaculture (AQUA) (NCRWQCB 2018). The MUN beneficial use designation is used to protect sources of human drinking water and has the most stringent water quality objectives. The MUN beneficial use applies to all groundwater in Butte Valley.

Section 3.4 and Table 3-1 of the Basin Plan outlines the water quality objectives for all groundwaters in the North Coast Region and those specific to the Butte Valley Hydrologic Area (NCRWQCB 2018). The Basin Plan refers to the California Code of Regulations for Domestic Water Quality and Monitoring Regulations (Title 22) for nearly all numeric limits (NCRWQCB 2018; State of California 2019). The Basin Plan water quality objectives and numerical limits are used in Section 2.2.2 of the GSP regarding water quality characterization and issues of concern. They also guide Chapter 3 of the GSP regarding groundwater sustainability criteria related to degraded water quality. No limitations to operational flexibility in GSP implementation are expected in the Basin due to implementation of the Basin Plan.

2.1.2.2 California Statewide Groundwater Elevation Monitoring Program

The California Statewide Groundwater Elevation Monitoring (CASGEM) Program collects and centralizes groundwater elevation data across the state, and makes them available to the public. The CASGEM Program was established in response to the passage of California State Senate Bill X7-6 in 2009. Currently, all CASGEM data are made available to the public through the interactive mapping tool on the CASGEM Public Portal website (DWR 2019b). Additionally, the full dataset can be retrieved from the California Natural Resources Agency (CNRA) Open Data website (CNRA 2019).

In Butte Valley, as of September 2019, there were 6 CASGEM wells and 40 wells designated as “voluntary” mapped within the Basin boundary, and an additional 18 voluntary wells immediately adjacent to the Basin (DWR 2019b). “Voluntary” status indicates that the well owner has contributed water level measurements to the CASGEM database, but the well is not enrolled in the CASGEM monitoring program.

Well monitoring under the CASGEM Program is ongoing. CASGEM water level data are used in the GSP to characterize historical Basin conditions and water resources (see Section 2.2.2) and will inform future management decisions. No limitations to operational flexibility in GSP implementation are expected in the Basin due to implementation of the CASGEM Program.

2.1.2.3 Butte Valley Irrigation District (BVID)

Butte Valley Irrigation District (BVID) manages the largest groundwater distribution and management network in the Basin serving approximately 5,000 acres (20 sq km) of farmland. BVID distributes water throughout the service area through a network of pipes. BVID only services agriculture customers and no domestic customers. Farms serviced by the irrigation district are allocated 2 acre-feet per acre per year (0.6 m/yr). BVID supplies water from approximately 20 wells within its 25 well network. BVID and BVWA have an agreement where both entities can divert water from Meiss Lake to farmland, however BVID has not exercised the agreement due to pumping costs and the poor quality of the lake water (Novick 1996).

BVID surface water and groundwater operations are important to all aspects of the GSP, from historical water quality data to land use to groundwater recharge. BVID will be a key partner for GSP implementation. BVID operations and management will likely affect operational flexibility in

GSP implementation in the Basin. The GSA will collaborate with BVID to balance flexibility of operations and management with GSP implementation in the Basin.

2.1.2.4 City of Dorris Municipal Water District

The City of Dorris has a small municipal water district serving approximately 938 residents (McKay 2019). Groundwater has supplied 100 percent of the district water supply since the town was founded in 1908 (Bray & Associates 2015; McKay 2019). The municipal water supply is pumped from a single well, Well #6, which was drilled in 1971 to a depth of 1,236 ft (377 m) (Bray & Associates 2015; McKay 2019). A back-up well, Well #4 (“Old Sandy”), is used for emergencies (Bray & Associates 2015; McKay 2019). “Old Sandy” was discontinued from use due to the production of an excessive amount of sand and elevated arsenic concentrations (Bray & Associates 2015). Well #6 is metered and approximately 142 million gallons (gal) of water was pumped in 2014 (Bray & Associates 2015). Groundwater is treated with chlorine at the well site (Bray & Associates 2015).

The City of Dorris is designated as a severely disadvantaged community (SDAC) and has struggled to obtain funding to maintain its water distribution lines (Bray & Associates 2015; DWR 2016b). Many of the water distribution lines in Dorris are the original lines installed over 100 years ago, and some sections of pipe installed in 1912 are still in use (Bray & Associates 2015). The City is applying for grants and looking to increase assessment fees under Proposition 218 to fund extensive replacement of and upgrades to the City’s water distribution system (Bray & Associates 2015; McKay 2019). In the early 1980s, a federal grant funded the construction of a 750,000-gal (2,840 m^3) welded steel water reservoir, which remains in use today (Bray & Associates 2015). Bray & Associates proposed a Capital Improvement Plan of several million dollars and recommend installation of water meters to encourage water conservation, a move that was estimated to reduce water consumption by 30% if implemented (Bray & Associates 2015). The City successfully received grants from the Department of Public Health Safe Drinking Water State Revolving Fund and State Revolving Fund to begin the Dorris Water Meter Installation Project in 2021. The project will install water meters, replace old pipelines, and locate missing services.

The Municipal Code of the City of Dorris includes a water conservation program (Title 13, Chapter 5). The City may order the appropriate stage of water conservation based on projected supply and customer demand. The three water stages with mandatory compliance applies restrictions to a variety of water-dependent activities such as landscape watering and car washing. The most severe water conservation stage applies water usage cuts for agricultural or commercial nurseries purposes and commercial, manufacturing, and processing processes.

City reports and data are used in the GSP to characterize historical Basin conditions and the City is expected to be a key partner for GSP implementation. City operations and management will likely affect operational flexibility in GSP implementation in the Basin. The GSA will collaborate with the City to balance flexibility of operations and management with GSP implementation in the Basin.

2.1.2.5 United States Forest Service

USFS manages the Klamath National Forest, of which the Butte Valley National Grassland is included. USFS manages the Mt. Hebron Work Center in the city of Mount Hebron and the Goosenest District Office, both of which have groundwater wells that report data to CDPH and SWRCB (SWRCB 2019a; SWRCB 2019b). The USFS also owns and manages Juanita Lake, with water rights to divert water from Seikel Creek (a tributary of Muskgrave Creek) to the lake (Novick 1996). From April 30 to November 1, 0.56 cfs can be diverted directly from Seikel Creek and 340 AF of water can be stored from November 1 to April 30 (Novick 1996).

USFS will be a key partner for GSP implementation. USFS land covers roughly 23% of the Basin surface area and coordination with the GSA will be important for GSP implementation. Butte Valley National Grassland operations and management will likely affect operational flexibility in the Basin. The GSA will collaborate with the USFS to align operations with GSP implementation in the Basin.

2.1.2.6 California Department to Fish and Wildlife

The Butte Valley Wildlife Area (BVWA) is managed by the California Department Fish and Wildlife (CDFW). In 1979 the California Legislature adopted Senate Concurrent Resolution No. 28 (SCR28) in 1979 to maintain existing wetlands and increase wetland acreage by 50 percent by the year 2000. Purchase of BVWA preserved its existing wetlands. CDFW is working on expanding BVWA wetlands by restoring former wetlands to functioning wetlands for wildlife habitat (Novick 1996). The BVWA management area is shown in Figure 1.7. CDFW manages 13,400 acres (54 sq km) of land that includes Meiss Lake and its surrounding land (DWR 1998). CDFW directly owns 13,200 acres and cooperatively manages lands owned by the US Bureau of Land Management (BLM) and the U.S. Forest Service (USFS). In the northwest corner of BVWA, BLM owns 80 acres managed for wildlife (field 11A). Adjacent to the southwest BVWA boundary, USFS owns 150 acres managed for wildlife (Novick 1996). Water resources in BVWA are used for irrigation and wetland maintenance (Novick 1996). Wetland expansion and management of Meiss Lake floodwaters have improved wildlife habitat, increased groundwater recharge for agricultural wells, improved forage for livestock in the National Grasslands, and reduced Siskiyou County pumping costs for flood protection [2009 BVWA Plan Addendum].

BVWA is managed as waterfowl habitat for the Pacific Flyway and provides foraging, resting and sanctuary areas for migratory birds. Resident waterfowl such as the Canada Goose and several duck species use BVWA for nesting, brood-rearing and molting. Three threatened or endangered species, including the bald eagle (state endangered status under review), sandhill crane, and Swainson's hawk use BVWA for hunting, nesting and foraging (Novick 1996; CDFW 2021c). Bald eagles are year round residents of BVWA with dozens of eagles during the winter [BVWA April 2021 GSP comments].

Within BVWA is 4,000 acre (16 sq km) Meiss Lake, managed wetlands and crop lands, meadows, creeks, native grasslands, brush fields and pine-oak forests (Novick 1996). The 8,400 acres of wetlands are maintained by 40 miles of dikes and levees, 31 miles of canals and channels, 325 nesting islands and over 150 water control structures (NCRWQCB 2008). Macdoel Ditch is a 0.8 mi long drainage canal leading from the east shore of Meiss Lake to the adjacent USFS Butte Valley National Grasslands that can transport lake water to the grasslands (Novick 1996; County of Siskiyou 1996). BVWA also includes riparian corridors along Ikes, Harris, Muskgrave and Prather Creeks, tributaries to Meiss Lake (Novick 1996). Cereal grain crops are grown for waterfowl food and include wheat, barley, oats, and rye (Novick 1996). Perennial crops are grown to provide nesting cover for ground nesting birds and include wheatgrass, alfalfa and native meadow hay. During the summer and fall, parts of the BVWA are flooded to provide brood habitat and habitat for migratory waterfowl, respectively (DWR 1998).

Water used to flood the BVWA ponds is generally provided by surface water supplies but is augmented or replaced with groundwater during surface water deficient periods (DWR 1998). Surface water supplies are typically sufficient for wetland flooding in the spring but insufficient in the summer and fall (Novick 1996). BVWA surface water comes from four creeks and one canal that flow toward Meiss Lake (Novick 1996). From the west, spring-fed Ikes, Harris, and Muskgrave Creeks flow into the Perimeter Canal, which flows to Meiss Lake (Novick 1996). From the south, spring-fed Prather Creek flows directly into Meiss Lake (Novick 1996). Estimated creek inflows are 15,000 to 20,000 acre-feet annually but are low or nonexistent in the summer and fall (Novick 1996). The Irrigated District Canal delivers excess irrigation water to Meiss Lake from wells and summer runoff, though flows are normally very low (Novick 1996). Meiss Lake is a managed reservoir with a depth no greater than 6 feet (Novick 1996). Lake depths greater than 6 feet cause flooding and subbage issues for adjacent private farmland (Novick 1996). Lake water increases in alkalinity in the summer and fall and is not suitable to flood wetlands or irrigate crops when surface water supplies are low (Novick 1996).

BVWA uses groundwater to meet its water demand when surface water supplies are insufficient, particularly in the summer and fall (Novick 1996; DWR 1998). BVWA has five deep irrigation wells, though only four are currently used for production: Wells 1, 2, 3, and 5A (Novick 1996). Wells 1, 2, and 3 tap into the High Cascade Volcanics water bearing formation (Novick 1996). Groundwater from the three wells is used to irrigate food and nesting cover crops and maintain water levels in the BVWA wetlands for summer brood water for resident birds (500–600 acres of wetland) and fall migrating birds (increase to 1,000–1,200 acres of wetland) (Novick 1996). The four wells are operated intermittently from June to August and continuously from September to the end of October, though the pumps will run longer in drought years (Novick 1996). In the southwest portion of BVWA, Wells 1, 2, and 3 are relatively shallow with depths of 90 to 284 feet (Novick 1996). The wells once had artesian flows of 15 to 500 gpm (Novick 1996). The artesian flows of Wells 1, 2, and 3, and several smaller domestic wells near BVWA headquarters stopped during the droughts of 1977, 1980-83, and from 1987 to Present (Novick 1996). Wells 1, 2, and 3 have water yields of 2,588, 1,377, and 1,460 gpm, respectively (Novick 1996). Well 7A is on the north side of BVWA with water yields of 2,500 gpm (Novick 1996). Groundwater pumping from the four wells has no to minimal impact on offsite irrigation wells (Novick 1996). Groundwater in the High Cascade water bearing formation near BVWA headquarters flows northerly then northeasterly (Novick 1996).

Wells 5A is located southeast of Meiss Lake and taps into the Butte Valley Basalt water bearing formation (Novick 1996). Groundwater from the well is only used to sprinkler-irrigate cereal grain crops in BVWA due to the seasonal depletion of the aquifer. It is 278 feet deep with water yields of 3,000 (Novick 1996). In the years 1981, 1991, 1992, and 1994, the well has gone dry near the end of the irrigation season when the Butte Valley Basalt water bearing formation was depleted (Novick 1996).

In 1998 the BVWA total annual water demand was 13,200 acre-feet (AF) (DWR 1998). From the 1980s to 1998, the annual BVWA groundwater extraction amount has varied from 2,000 AF to 5,300 AF, with an average annual amount of approximately 3,000 AF (DWR 1998). The average groundwater demand was expected to increase to 3,500 AF due to a proposed 500 AF increase in groundwater development (DWR 1998). However the actual long-term average use (1987 - 2008) has actually decreased to 2,746 AF [2009 BVWA Plan Addendum]. As of 1998, the BVWA applied groundwater demand was about 1.1 acre-feet per acre (DWR 1998).

In 1998, DWR investigated DFG Well 7A (27C01M), located north of Meiss Lake, for an unacceptable level of interference with neighboring wells and springs (DWR 1998). Well 7A taps into the highly transmissive High Cascade Volcanics water bearing formation and was confirmed to cause interference with adjacent wells but had minimal impact on nearby springs located on Holzhauser

Ranch in Sam's Neck (DWR 1998). Additionally, the 1998 DWR well interference study found that groundwater flow around Well 7A is noticeably influenced by nearby faults, which can act as both a flow barrier and a very transmissive conduit for flow (DWR 1998). CDFW altered use of Well 7A in a desire to be a good neighbor and minimize possible effects on the wells of private neighbors [2009 BVWA Plan Addendum]. Actions included reduction of volume pumped from Well 7A from 2,800 gpm to 1,500 gpm and overall operation is coordinated with adjacent private landowners to minimize any impacts on their irrigation wells [2009 BVWA Plan Addendum].

CDFW will be a key partner for GSP implementation. CDFW land covers roughly 17% of the Basin surface area and coordination with the GSA will be important for GSP implementation. CDFW reports and data are used to characterize the Basin in Section 2.2 of the GSP. CDFW operations and management will likely affect operational flexibility in GSP implementation in the Basin. CDFW groundwater extraction may potentially impact neighboring wells and the resulting cone of depression may be asymmetrical due to local faults (DWR 1998). The GSA will collaborate with the CDFW to align operations with GSP implementation in the Basin.

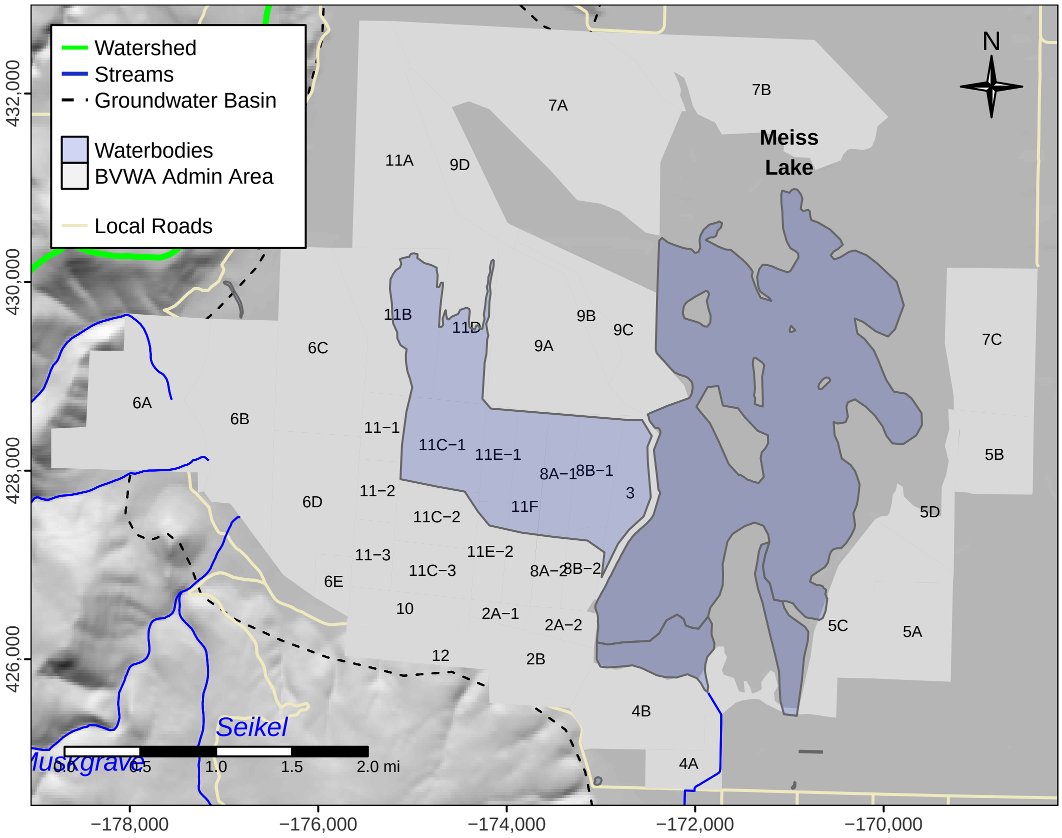


Figure 1.7: Map of the Butte Valley Wildlife Area adapted from the 1996 draft management plan for the wildlife area.

2.1.2.7 United States Bureau of Reclamation (USBR)

Through USBR's WaterSMART program, Reclamation is granting funds to the Agency to install 10 co-located, continuous groundwater level and soil moisture sensors that will be incorporated into the Basin's GSP development and implementation. The GSA will collaborate with the USBR to align operations with GSP implementation in the Basin.

2.1.2.8 Endangered Species Conservation Laws

Federal Endangered Species Act (ESA)

The Endangered Species Act of 1973 (ESA) outlines a structure for protecting and recovering imperiled species and their habitats. Under the ESA, species are classified as "endangered," referring to species in danger of extinction throughout a significant portion of its range, or "threatened," referring to species likely to become endangered in the foreseeable future. The ESA is administered by two federal agencies, the Interior Department's U.S. Fish and Wildlife Service (FWS), primarily responsible for terrestrial and freshwater species, and the Commerce Department's National Marine Fisheries Service (NMFS) which primarily handles marine wildlife and anadromous fish.

California Endangered Species Act (CESA)

The California Endangered Species Act (CESA) was first enacted in 1970 with the purpose of conserving plant and animal species at risk of extinction. Similar to the ESA, CESA includes the designations "endangered" and "threatened," used to classify species. Definitions for these designations are similar to those under the ESA and apply to native species or subspecies of bird, mammal, fish, amphibian, reptile, or plant. An additional category "candidate species" exists under CESA that includes species or subspecies that have been formally noticed as under review for listing by the California Department of Fish and Wildlife. Additional detail on other species in Shasta River Valley listed under CESA can be found in Section 2.2.1.7 as part of the discussion on groundwater dependent ecosystems (GDEs).

Both the ESA and CESA are used in the GSP to guide the identification of key species for consideration as part of groundwater dependent ecosystems. Listed species will continue to be considered throughout GSP implementation, as part of any project and management actions, and to help inform future management decisions. These endangered species conservation laws may limit operational flexibility in GSP implementation. The GSA will incorporate this legislation into its decision-making and may seek to coordinate with the relevant state and federal lead agencies, as necessary.

2.1.3 Land Use Elements or Topic Categories of Applicable General Plans

2.1.3.1 General Plans

The overarching framework for land use and development in the County of Siskiyou (County) is the Siskiyou County General Plan (General Plan). A community-specific General Plan was also developed in Butte Valley for the City of Dorris. Elements of the General Plans outline goals for land use and development, and mechanisms for achieving those goals that include policies and zoning regulations. The GSP will be developed to conform with the general plans as much as possible.

County of Siskiyou General Plan

The County's General Plan (County of Siskiyou 2019b) serves as a guide for land use decisions within the County, ensuring alignment with community objectives and policies. While the General Plan does not prescribe land uses to parcels of land, it does identify areas that are not suitable for specific uses. The components of the General Plan with the most relevance to the GSP include the Conservation Element and Open Space Element. Many of the objectives and policies within the General Plan align with the aims of the GSP and significant changes to water supply assumptions within these plans are not anticipated.

The Conservation Element of the General Plan recognizes the importance of water resources in the County and outlines objectives for the conservation and protection of these resources to ensure continued protection of beneficial uses for people and wildlife. Methods for achieving these objectives include local legislation such as flood plain zoning and mandatory setbacks, subdivision regulations, grading ordinances, and publicly managed lands to ensure preservation of open spaces for recreational use. The importance of water resources is clearly noted in this element: "Groundwater resources, water quality, and flood control remain the most important land use determinants within the county" (County of Siskiyou 1973). Specific topics addressed include preventing pollution from industrial and agricultural waste, maintaining water supply and planning for future expansion, reclaiming and recycling wastewater, and protecting watershed and recharge lands from development. These objectives in the Conservation Element mirror the objectives of the GSP, namely ensuring a sustainable water supply, the protection and preservation of watershed and water recharge lands, and prevention of degradation of water quality.

The Open Space Element of the General Plan includes in its definition of open space any area of land that serves as open space, watershed and groundwater recharge land, among other uses. The importance of protecting these lands is recognized for maintaining water quality and quantity. Mechanisms to preserve these spaces include maintaining or creating scenic easement agreements, preserves, open space agreements, and the designation of lands for recreational or open space purposes. A policy for open space requirements is included with minimum thresholds of 15% of proposed developments as open space. Protection of open space for habitat, water quality, and water quantity align with the objectives of the GSP.

Siskiyou County Zoning Plan

The County of Siskiyou Zoning Plan (Zoning Plan) is codified in Title 10, Chapter 6 commencing with Article 37 (County of Siskiyou 2019a). The County of Siskiyou Zoning Ordinance outlines the permitted types of land use within each zoning district. Zoning categories include residential, commercial, industrial, agricultural, forestry, open space, and flood plains. Many of the purposes and policies of the Zoning Plan align with the objectives of the GSP. In particular, the “wise use, conservation, development and protection” of the County’s natural resources, protection of wildlife, and prevention of pollution support the objectives of the GSP. Mechanisms to achieve these goals include permitted and restricted uses for land parcels, and requirements and stipulations for land use and development.

2.1.3.2 Community Plans

Dorris General Plan

The City of Dorris General Plan (DGP) outlines objectives and programs to guide decision-making as it relates to land use and development to ensure the physical, economic, and social wellbeing of the community. The DGP is applicable through Year 2025 (updated in 2007) and incorporates all elements, as required by Section 65402 of the California Government Code: land use, circulation, housing, conservation, open space, noise, and safety (City of Dorris 2007).

2.1.3.3 Williamson Act Land

Contracts under the California Land Conservation Act of 1965, commonly known as the Williamson Act, are used to preserve open space and agricultural lands. Local governments and private landowners enter into voluntary agreements to restrict land for use in agriculture or as open space. Private landowners that enter into a Williamson Act contract benefit from lower property taxes. Lands that are eligible to be enrolled under these contracts must be a minimum of 100 acres and can be enrolled as either Prime or Non-Prime Williamson Act Farmland, based on the productivity specifications outlined in Government Code § 512021. In the County of Siskiyou, as of 2014, 96,993 acres (393 sq km) were enrolled as Prime Land and 324,300 acres (1,312 sq km) were enrolled as Non-Prime Land (California Department of Conservation (DOC) 2016).

2.1.3.4 Neighboring Groundwater Basins

The Butte Valley groundwater basin has several neighbors that could affect the ability of the GSA to achieve sustainable groundwater management: Tule Lake, Lower Klamath, Red Rock Valley, and Shasta Valley groundwater basins. DWR lists Tule Lake and Shasta Valley groundwater basin as medium priority basins, while the Lower Klamath and Red Rock Valley's are low priority (https://gis.water.ca.gov/app/bp-dashboard/final/).

[Work in Progress - Pending discussions with neighboring GSAs and review of GSPs]

2.1.4 Additional GSP Elements

2.1.4.1 Policies Governing Wellhead Protection and Well Construction, Destruction and Abandonment

In the Basin, wellhead protection and well construction, destruction and abandonment are conducted according to relevant state guidelines.

Well standards are codified in Title 5, Chapter 8 of the Siskiyou County Code. These well standards define minimum requirements, including those for monitoring wells, well construction, deconstruction, and repair, with the objective of preventing groundwater pollution or contamination (County of Siskiyou, n.d.). Processes and requirements for well permitting, inspections, and reporting are included under this chapter of the County Code of Ordinances.

The County of Siskiyou Environmental Health Division (CSEHD) is the local enforcing agency with the authority to issue well permits in the County. Well permit applications require information from the applicant and an authorized well contractor, along with a fee.

The County has worked on obtaining hydrological data/modeling to help inform individual well permitting decisions beginning with the Scott Valley; and public discussion and decision making related to the impacts of the public trust doctrine on groundwater management is on-going. The GSA will look for opportunities to coordinate with the County on providing collected hydrologic information that may assist the County.

2.1.5.2 Groundwater Extraction and Illegal Cannabis

On August 4, 2020, Ordinance 20-13 amended Chapter 13 of Title 3 of the County Siskiyou Code of Ordinances to add Article 7. Article 7 defines finds extracting and discharging use of groundwater for illegal cultivation of cannabis to be a public nuisance and a waste and/or unreasonable use of groundwater and prohibits extraction and discharge of groundwater underlying the County for this activity. Ordinance 20-13 was replaced by Ordinance 20-15 in the fall of 2020; however, the substantive provisions of the ordinance remain the same.

A current and recently expanding (5 to 7 years) land use practice is not accounted for in either the historical or future water budget analysis nor groundwater extraction for the cultivation of illegal cannabis.

Siskiyou County has adopted multiple ordinances relating to the regulation of cannabis. Chapter 15 of Title 10 of the Siskiyou County Code prohibits all commercial cannabis activities, and

Chapter 14 limits personal cannabis cultivation to the indoor growth of a maximum of 12 plants on premises with a legal water source and an occupied, legally established residence connected to an approved sewer or septic system. Personal cultivators are also prohibited from engaging in unlawful or unpermitted surface drawing of water and/or permitting illegal discharges of water from the premises. Despite these ordinances, illegal cannabis cultivators continue to operate within and near the Basin.

Illegal cannabis growers rely on groundwater from production and residential well owners and utilize water trucks to haul groundwater off the parcel from which it is extracted for use at other locations. The proliferation and increase of illegal cannabis cultivation taking place in the Basin is a significant community concern, however, obtaining an accurate estimate of overall consumptive groundwater use for this illegal activity has been a challenge for the GSA due to it occurring on private and secluded parcels and the increasing use of covered greenhouses for illegal cannabis cultivation. Future model scenarios may use an estimated number of cannabis plants from the Siskiyou County Sheriff Department and a consumptive use of 4-10 gallons of water per plant per day, to consider the potential impacts to groundwater resources from this activity under current and future conditions.

In addition to community concern about estimated consumptive use of groundwater in the basin for illegal cannabis cultivation, there is also concern about water quality impacts from the potential use of illegal and harmful chemicals at illegal grow sites, which may leach into the groundwater (see Chapter 2, Water Quality), and the non-permitted human waste discharge methods that have been found to occur at some of these sites. Data on baseline water quality conditions at illegal cannabis cultivation sites within the Basin or at nearby wells has not been collected, however, the GSA intends to include available wells within close proximity to these sites in its future monitoring network for the purpose of measuring water quality.

The GSA considers groundwater used for illegal cannabis cultivation to be a “waste and unreasonable use of water,” but acknowledges that there is not substantial enough data to include groundwater the use estimates from illegal cannabis production in the overall and future water budgets. The GSA will coordinate with local enforcement agencies regarding providing collected hydrologic information and will also use the emphasis on collecting data during the first 5 years of plan implementation to better understand the impacts of groundwater use for illegal cannabis on overall Basin-wide use estimates and the relation to nearby groundwater aquifers.

2.1.4.3 Groundwater Export

Groundwater export is regulated in the County under Title 3, Chapter 13 of the Siskiyou County Code. Since 1998, Chapter 13 has regulated the extraction of groundwater from Bulletin 118 basins underlying the County for use outside of the basin from which it was extracted. Exceptions include 1) groundwater extractions by a district purveyor of water for agricultural, domestic, or municipal use where the district is located partially within the County and partially in another county, so long as extracted quantities are comparable to historical values; and 2) extractions to boost heads for portions of these same water purveyor facilities, consistent with historical practices of the district. Groundwater extractions for use outside the County that do not fall within the exceptions are required to obtain a permit for groundwater extraction. Permit application processes, timelines, and specifications are described in this ordinance.

In May of 2021, Title 3, Chapter 13, was amended to add Article 3.5, which regulates, through ministerial permitting, the extraction of groundwater for use off the parcel from which it was extracted.

This provision requires extracted groundwater be for uses and activities allowed by the underlying zoning designation of the parcel(s) receiving the water and does not apply to the extraction of water for the purposes of supplying irrigation districts, emergency services, well replenishment for permitted wells, a “public water system,” a “community water system,” a “noncommunity water system,” or “small community water system” as defined by the Health and Safety Code, serving residents of the County of Siskiyou.

2.1.4.3 Policies for Dealing with Contaminated Groundwater

Migration of contaminated groundwater from point sources, such as leaking fuel tanks, is managed through coordination with NCRWQCB. Open and historic (“closed”) cleanup sites are discussed in Section 2.2.2.3, subsection “Contaminated Sites.” Non-point sources of contaminated groundwater, such as pesticides, are described in Section 2.2.2.3.

2.1.4.5 Replenishment of Groundwater Extractions and Conjunctive Use

There are no artificial groundwater replenishment or conjunctive use projects in Butte Valley. Proposed projects and management actions are described in Chapter 4.

2.1.4.6 Coordination with Land Use Planning Agencies

The GSA will manage land use plans and coordinate land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity.

2.1.4.7 Relationships with State and Federal Regulatory Agencies

The GSA has relationships with multiple state and federal agencies, as described in the Section 2.1.2 Monitoring and Management Programs. These state and federal agencies include CDFW, NCRWQB, USFS, DWR, and USBR. The GSA will continue to coordinate and collaborate with these agencies throughout GSP development and implementation.

2.2 Basin Setting

2.2.1 Hydrogeologic Conceptual Model

Executive Summary

Butte Valley (Valley) is a topographically closed internally drained basin at the boundary between the western Modoc Plateau and eastern Cascade Range geomorphic provinces, near the western and northwestern border of the Medicine Lake Highlands (William A. Bryant (1990)). The Valley experiences east-west directed extensional tectonics and north-trending normal faults expressed as block faulting (William A. Bryant (1990)). This chapter reviews the background of the hydrogeologic conceptual model. A hydrogeologic conceptual model (HCM) (DWR 2016a) fulfills the following:

1. *Provides an understanding of the general physical characteristics related to regional hydrology, land use, geology and geologic structure, water quality, principal aquifers, and principal aquitards of the Basin setting;*
2. *Provides the context to develop water budgets, mathematical (analytical or numerical) models, and monitoring networks; and,*
3. *Provides a tool for stakeholder outreach and communication.*

The following is a graphical and narrative description of the physical components of the Basin. The following elements as required by DWR (DWR 2016c):

- Scaled cross-sections.
- Topographic information.
- Surficial geology.
- Soil characteristics.
- Delineation of existing recharge areas that substantially contribute to the replenishment of the Basin, potential recharge areas, and discharge areas.
- Surface water bodies.
- Source and point of delivery for local and imported water supplies.

2.2.1.1 Topography

Butte Valley (Valley) is a structurally controlled closed drainage basin and the valley floor is a practically flat surface, with elevations ranging over an exceedingly narrow range from 4,226-4,236 ft (1,288-1,291 m) amsl, shown in Figure 1.8 (William A. Bryant 1990; County of Siskiyou 1996). The Butte Valley watershed is roughly three times larger than the Butte Valley groundwater Basin. As shown in Figure 1.13, the flat-floored structural depression is surrounded by youthful fault scarps and merges into fields of broken Quaternary basalts to the south (DOI 1980). The mountainous topography that bounds the basin ranges from 5,000-8,000 ft (1,524-2,438 m) amsl (DWR 1968). The Basin is bounded in the north, south and west by the Cascade Mountains and on the southeast by Sheep Mountain and Red Rock Valley (Wood 1960; DWR 2004). Topography to the north is marked by block-faulted volcanic plateaus and several flat-floored grabens, including Sam's Neck and Pleasant Valley, that project beyond the Basin (DOI 1980; William A. Bryant 1990). The eastern boundary has a prominent northwestward trending fault block (the Mahogany Mountain ridge or Mahogany Ridge), which isolates the Basin from the Lower Klamath Lake marshland in the northeast (DWR 2004). The Mahogany Ridge is 20 mi (32 km) long, 1-3 mi (1.6-4.8 km) wide and bordered by steep, slightly dissected, talus-covered fault scarps (DOI 1980). The north end of the ridge is broken by several en-echelon faults while the south end is characterized by a gently southward sloping plateau (DOI 1980).

The Watershed is immediately northeast of Mount Shasta, seen in the bottom left corner of Figure 1.8. The northern Watershed border crosses the state border into Oregon, with the northernmost extent bounded between Chicken Hills and Hamaker Mountain (cf. USGS topo maps). In Oregon, Grenada Butte and Randolph Flats are within the Watershed. In addition to Butte Valley, the Watershed includes Red Rock Valley (northeast of Cedar Mountain), Round Valley (between Cedar Mountain and Orr Mountain), the Bray Town Area (south of Orr Mountain), plus other unnamed valleys.

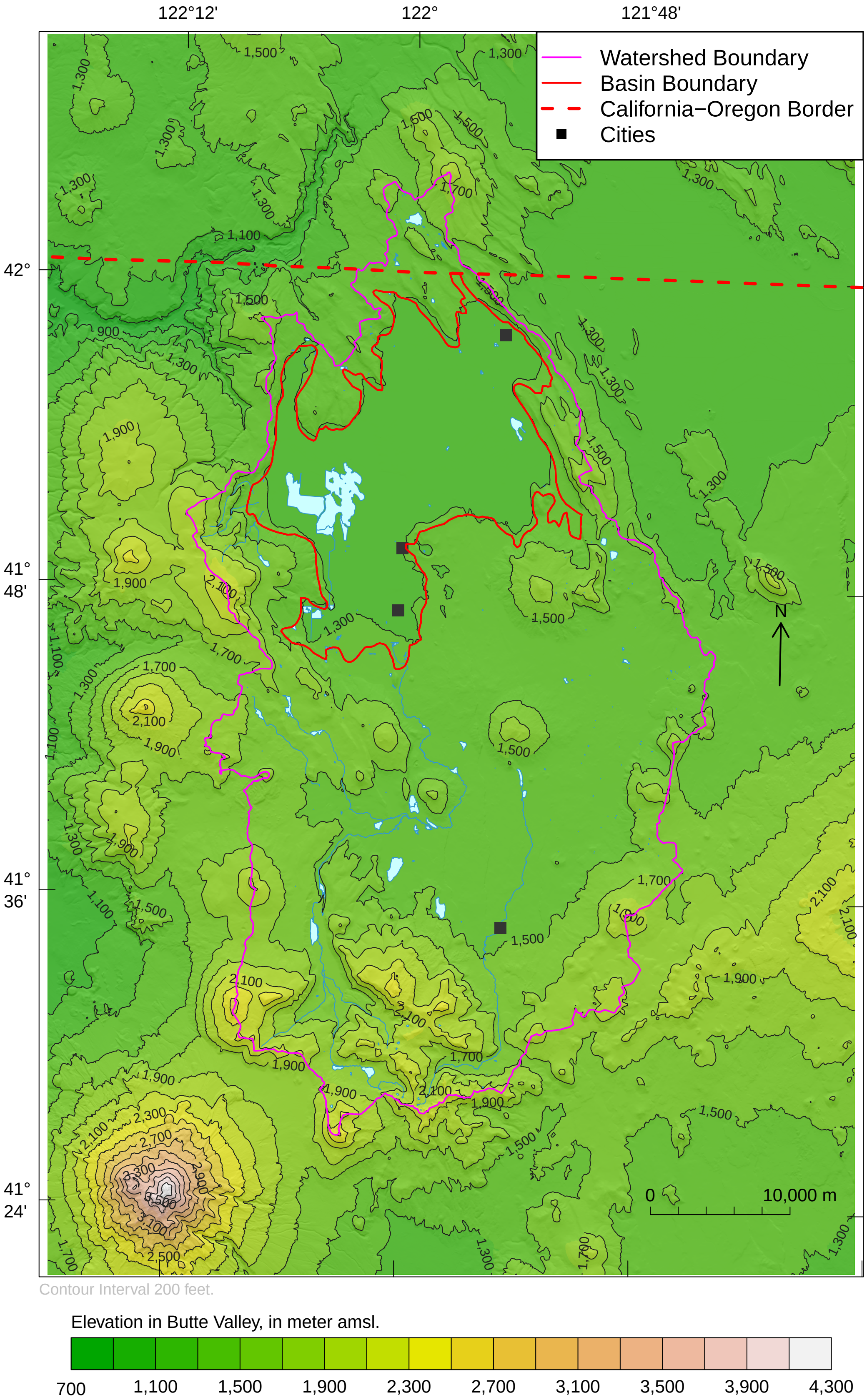


Figure 1.8: Topography of the Butte Valley Groundwater Basin and surrounding watershed. City names from north to south are: Dorris, Macdoel, Mount Hebron and Tennant.

2.2.1.2 Climate

Butte Valley has a semiarid climate characterized by warm, dry summers and cool, wet winters. The Cascade Range on the west side of the Valley casts a rain shadow across the Basin, where precipitation is highest on the west side of the valley and decreases eastward (Novick 1996). Annual precipitation also increases northward (DWR 2004). In 1996, the mountains and foothills on the west side of the Butte Valley Wildlife Area received an average of 20 to 28 inches of rainfall a year, the crop lands on the west side of Meiss Lake received 15-22 inches, BVWA headquarters received 18 inches, and the east side of Meiss Lake received 10 to 12 inches (Novick 1996). Snow can occur during any month of the year but normally falls between November and March (Novick 1996). July through September are historically the driest months (DOI 1980)Figure 1.9. Long-term climate records are available from National Oceanic and Atmospheric Administration (NOAA) weather stations in the Butte Valley watershed; relevant stations are listed in Table 1.2.

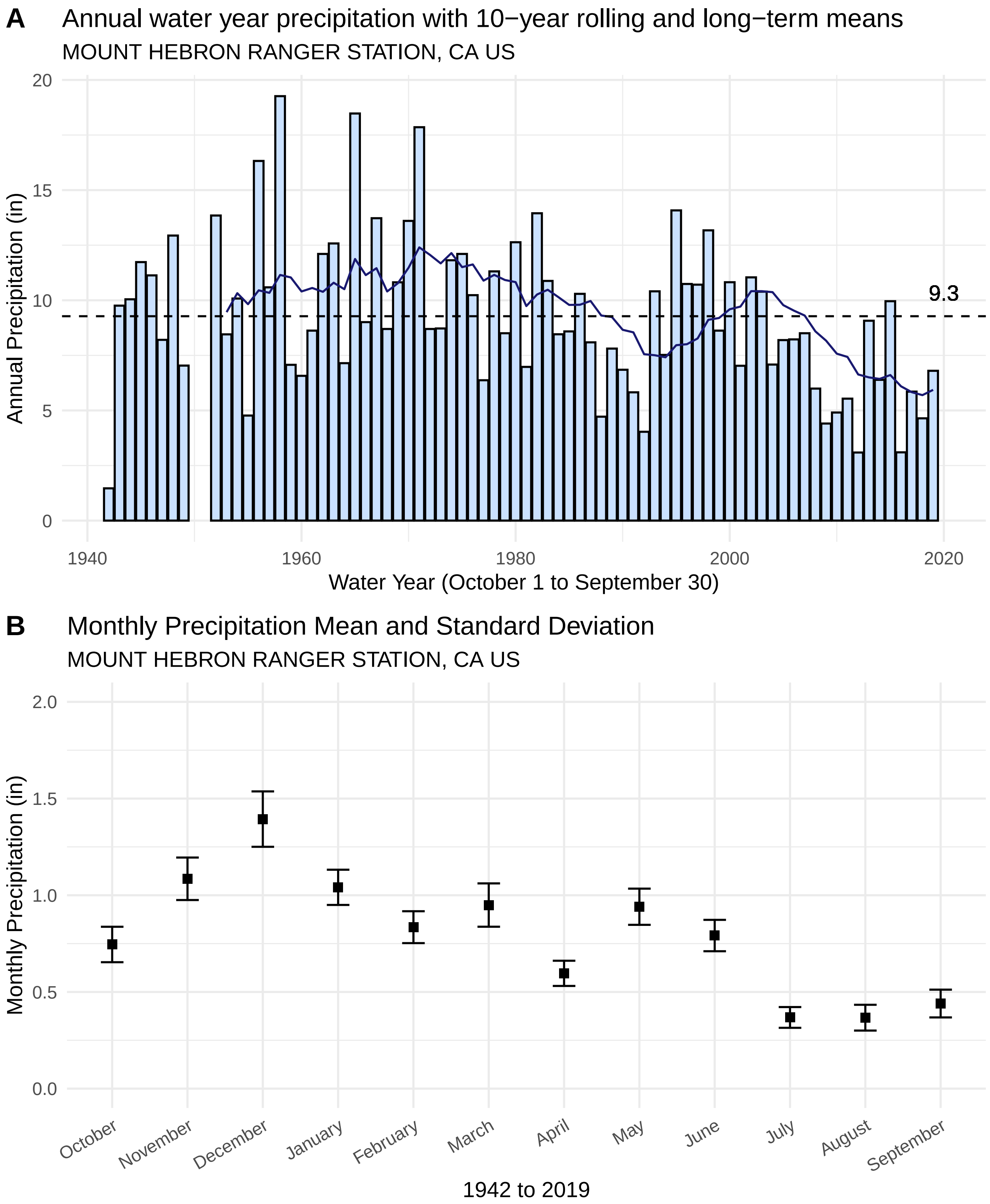
The Valley has experienced decreasing precipitation during much of the period between 1970 to 2020. From the 1940s to 2020, the NOAA station in Mount Hebron has an average annual precipitation of 9.3 inches Figure 1.9. Between 1942 and 1979, the 10-year trailing rolling average precipitation ranged from 9.5 to 12.4 in (24.1–31.5 cm; water years 1953 and 1971, respectively); since 1980, it has ranged between 5.7 and 10.8 inches (14.5–27.4 cm;water years 2018 and 1980, respectively; Figure 1.9). Much of the expansion in agricultural land in Butte Valley occurred before 1976, with irrigated land expanding to 11,130 hectares (27,500 acres), during a period when average rainfall was relatively stable and significantly greater.

Mean daily low and high temperatures for January and July are -8 to 7°Celsius (C) (17-44°Farenheit (F)) and 5 to 29°C (41-84°F), respectively (Figure 1.10). Temperature extremes range from over 38°C (100°F) in the summer to below -18°C (0°F) in the winter (DOI 1980). Reference evapotranspiration (ET) ranges from 0.002 to 0.33 in/day (0.005-0.84 cm/day) (Figure 1.10). Pan evaporation in Butte Valley is estimated to be 48 inches a year, with wind mainly responsible (Novick 1996). Figure 1.11 illustrates the recent climate shift by comparing the average temperature in the past 15 years to historical records. In the past 15 years, the average maximum and minimum air temperature increased roughly 1 to 5 F Figure 1.11.

Historically, killing frosts could occur at any time of the year and the growing season in Butte Valley was limited by the last and first killing frosts (<28°F). The growing season generally extended from May to October but frequent killing frosts in May and June usually shortened the usable growing season. The average growing season was roughly 100 days but varied greatly. In 1952, only one day was frost-free. A short growing season and frost danger limited the type and amount of agricultural crops grown within Butte Valley (DOI 1980; Novick 1996). Crops in BVWA were limited to hardy cereal grains and quickly maturing plants, which have marginal commercial value due to frost damage (Novick 1996).

Over the past few decades, the frost danger in Butte Valley has decreased Figure 1.12. The yearly average of days with temperatures less than 32 F has sharply declined since the 1980s. In recent years, strawberry crops have become increasingly important in the Valley.

Snow measurements in the Butte Valley watershed is a climate data gap. The nearest California Data Exchange Center (CDEC) weather stations are outside the watershed boundary. None of the NOAA weather stations in the watershed are situated in the west or south mountains, which are important to surface and groundwater recharge.



A Annual water year precipitation with 10−year rolling and long−term means

MOUNT HEBRON RANGER STATION, CA US

B Monthly Precipitation Mean and Standard Deviation

MOUNT HEBRON RANGER STATION, CA US

Figure 1.9: Annual (Panel A) and monthly precipitation (Panel B) over the 1942-2019 record as measured at the Mount Hebron Ranger weather station (USC00045941). In Panel A, the 10-year rolling average is shown as the average over the entire period of record. Each bar represents one water year, the total precipitation during the period between October 1 and September 30. Only the years 1950 and 1951 had significant data gaps and were removed.

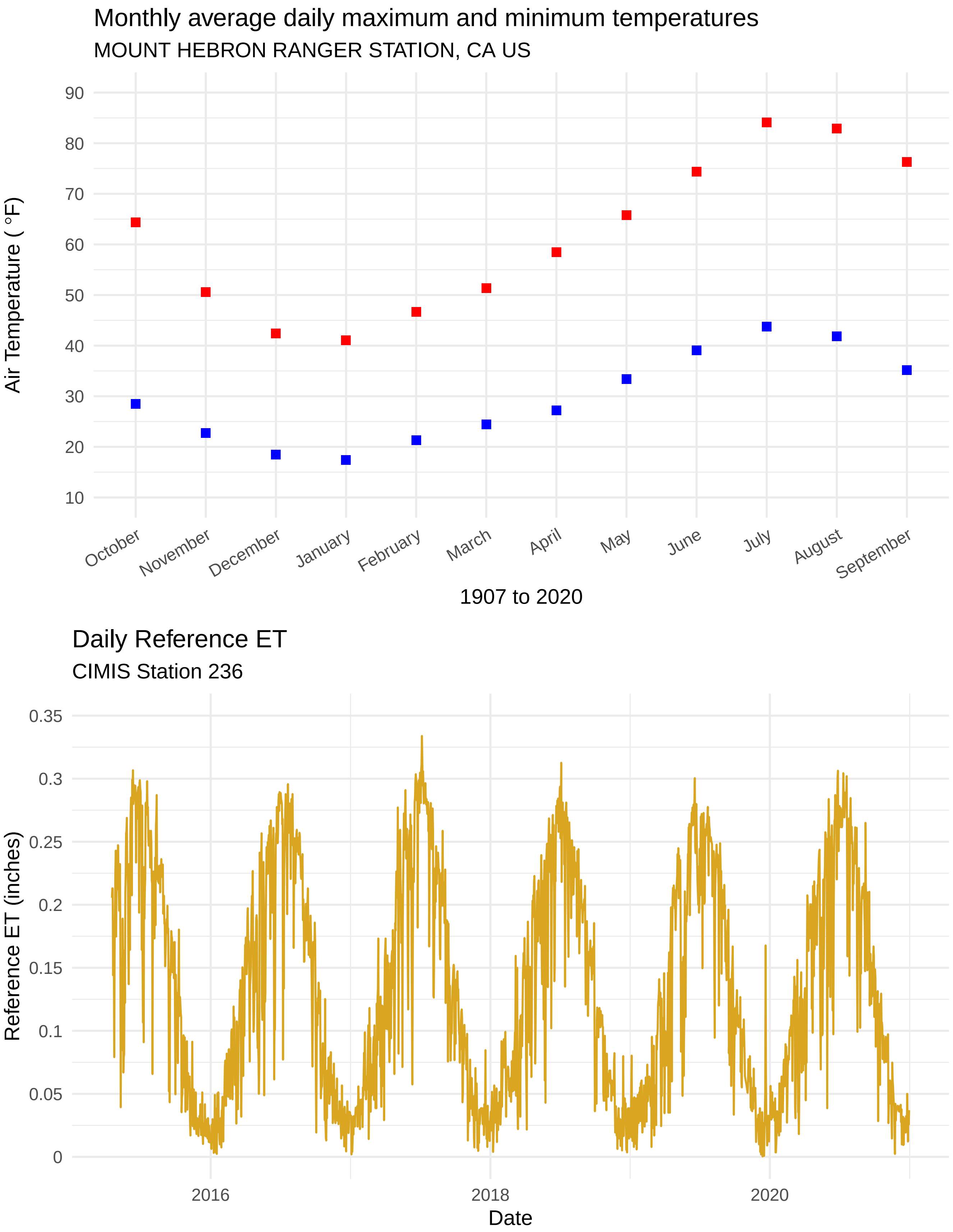


Figure 1.10: Monthly averages of daily maximum and minimum air temperature (top panel) over the 1942-2020 record at the Mount Hebron Ranger Station (USC00045941), and reference evapotranspiration (ET) from 2015-2020 calculated at CIMIS Station 236 between Macdoel and Mount Hebron.

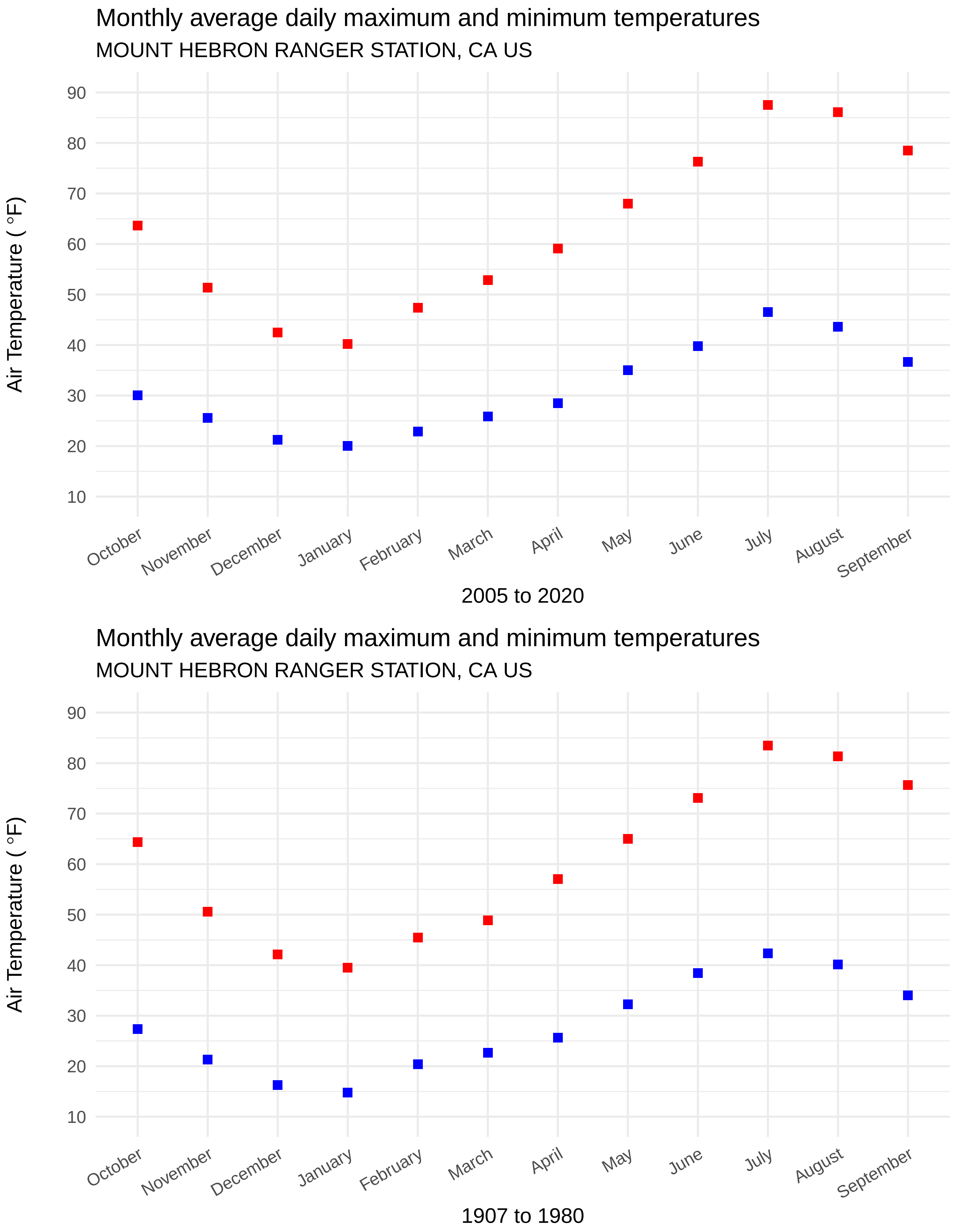


Figure 1.11: Monthly averages of daily maximum and minimum air temperature (top panel) over the 1942-1980 and 2005-2020 record at the Mount Hebron Ranger Station (USC00045941), which shows the recent warming of the Valley.

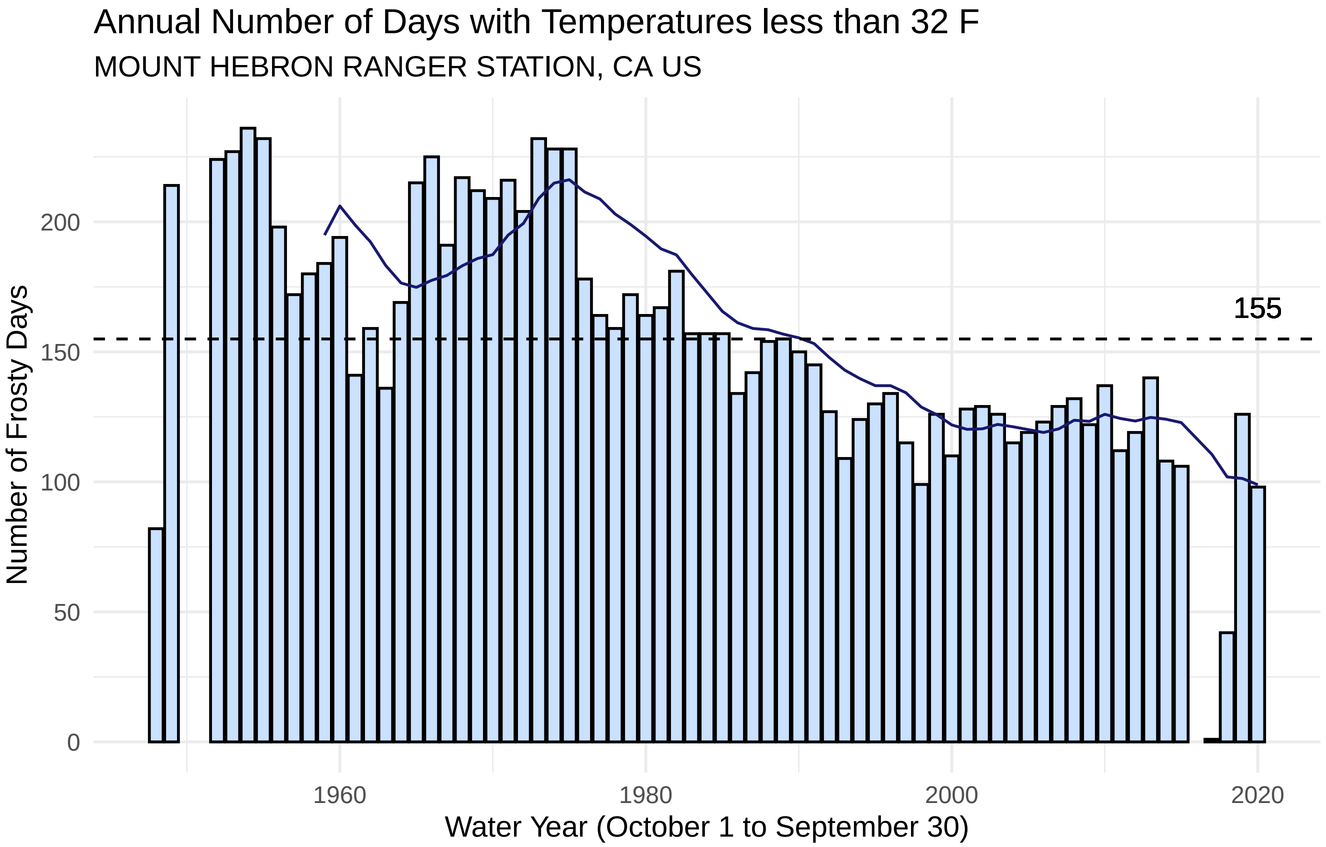


Figure 1.12: Total number of days with temperature minimums less than 32 F, representing frost potential. Totals are occasionally impacted by station equipment outtages.

Table 1.2: Station details and record length for NOAA weather stations in the Butte Valley watershed.

Station ID	Station Name	Elevation (ft amsl)	Start Date	End Date	Record Length (years)	No. Missing Days
US1CASK0010	DORRIS 0.2 SW, CA US	4,249	1998-06-17	2021-06-27	23.0	1
USC00045940	MOUNT HEBRON 11 ESE, CA US	4,383	1952-05-01	1960-12-31	8.7	7
USC00045941	MOUNT HEBRON RANGER STATION, CA US	4,250	1907-01-01	2020-04-01	113.2	1,956
USC00048860	TENNANT, CA US	4,754	1952-05-01	1957-08-31	5.3	3
USR0000CJUA	JUANITA LAKE CALIFORNIA, CA US	5,400	1988-12-30	2021-06-27	32.5	11,102
USR0000CVAN	VAN BREMMER CALIFORNIA, CA US	4,928	1993-06-01	2021-06-27	28.1	9,921

2.2.1.3 Geologic History

The oldest rocks near Butte Valley were formed between the Eocene to Miocene (56-5.3 million years ago (Ma)) during the formation of the Western Cascades (DOI 1980). The predominantly andesite volcanic rocks consist of interbedded basalts, dacites, rhyolite tuffs, and breccias (DOI 1980). At the end of the Miocene (~5.3 Ma), the original Western Cascade landscape and parent cones were destroyed by uplift and erosion (DOI 1980). During the same period, the regional uplift created the ancestral Cascade Range and a series of northwest-trending faults that cut through the Western Cascades (DOI 1980). From the late Pliocene to the Pleistocene (3.6-0.012 Ma), volcanism reactivated in the region, forming a north-trending series of broad shield volcanoes along the crest of the ancestral Cascades (DOI 1980). These volcanoes erupted the highly fluid basalts and andesites found in the High Cascade volcanic rocks in Butte Valley (DOI 1980). The present Cascade Range was formed later in the Pleistocene (2.6-0.012 Ma) through the eruptions of andesites, dacites, and rhyolites (DOI 1980). Sometime in the Pleistocene (2.6-0.012 Ma), faulting began to form the structural depression that would become Butte Valley (DOI 1980). The Basin became a closed drainage basin as the Valley dropped and adjacent fault block mountains uplifted (County of Siskiyou 1996). At the same time Meiss Lake occupied the Valley depositing the Lake Deposits on the valley floor (DOI 1980). During the Quaternary (2.6 Ma-Present), glaciation occurred in the high mountains that form the headwaters of Butte Creek, the largest creek in the Valley (King 1994). Glaciation created glacial moraines and cirque valleys at the Butte Creek headwaters (King 1994). From the end of the Pleistocene to Present (0.012 Ma-Present), renewed volcanic activity erupted large amounts of fluid basalts from fissures in the High Cascades, including the Butte Valley Basalt (DOI 1980). This recent volcanic activity has shrunk the Butte Valley watershed by cutting off small drainages such as the Grass Lake area (King 1994). Today, the Cascade Range continues to be volcanically active. Butte Valley also remains seismically active (DOI 1980).

2.2.1.4 Geologic Units

The surface geology of Butte Valley and adjacent regions are primarily volcanic with lake deposits, alluvial fan deposits, and alluvium with some deposits of dune sand and talus (Wood 1960). A generalized geologic map of the Butte Valley watershed is shown in Figure 1.13 and described in Table 1.3 (Wood 1960; Jennings et al. 2013). Cross-sections A-A' through C-C' are shown in Figure 1.14, Figure 1.15, Figure 1.16. A 1,573 ft (479 m) deep test well drilled in 1978 by the U.S. Department of the Interior (DOI) in the south side of the Valley offers an example of Butte Valley stratigraphy (DOI 1980): from 0–47 ft (24–137 m) depth is alluvium deposits, from 47–78 ft (14–24 m) depth is Butte Valley Basalt, from 78–1,317 ft (24–401 m) is Lake Deposits (where 78–450 ft (24–137 m) is sands and gravels with thin clay interbeds, and 450–1,279 ft (137–390 m) is predominantly clay), and 1,279 to greater than 1,573 ft (390–479 m) is High Cascade Volcanics. Similar stratigraphy appears in Cross-section A-A' between 400 to 12,000 m distance Figure 1.14. In other parts of the valley, the Butte Valley Basalt disappears and the stratigraphy is limited to lake sediments and High Cascade Volcanics, shown in Figure 1.14, Figure 1.15, and Figure 1.16. The following outlines the geologic units from oldest to youngest, separating the volcanic and sedimentary deposits.

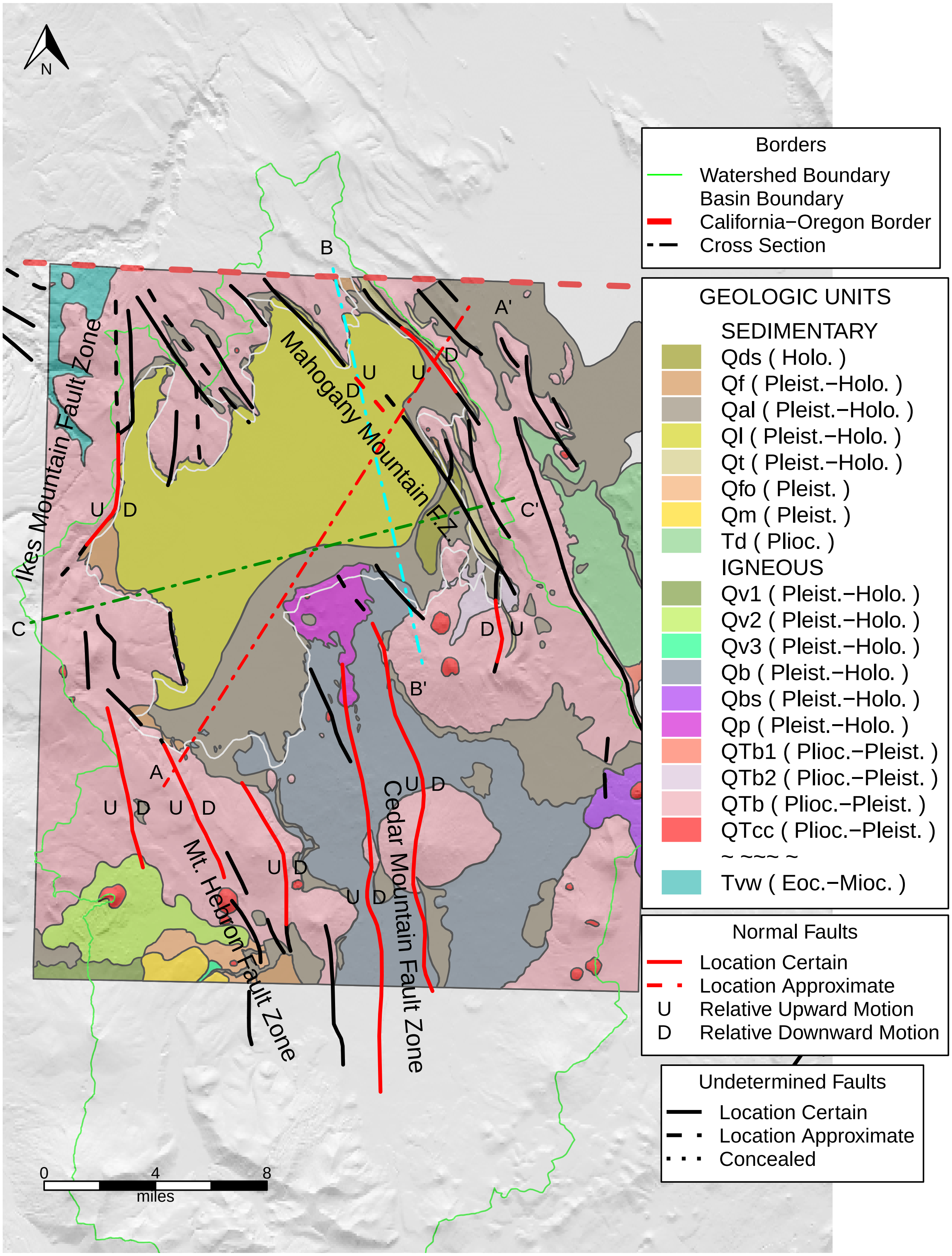


Figure 1.13: Geology of the Butte Valley Groundwater Basin and surrounding watershed. Fault zones are plotted with their major faults (minor faults not plotted). Legend abbreviations include the time periods Holocene (H.), Pleistocene (Pleist.), Pliocene (Plioc.), Miocene (Mioc.) and, Eocene (Eoc.). Geology layer from Wood, 1960 and faults from

Table 1.3: Geology Map Unit Descriptions (Wood 1960).

Unit Name	General Lithology	Age	Description
Qds	Dune Sand	Holocene	Unconsolidated sand, in part actively drifting.
Qf	Alluvial-fan deposits	Pleistocene-Holocene	Unconsolidated deposits consisting of poorly sorted boulders, gravel, sand, and silt beneath alluvial fans. Also includes remnants of older alluvial-fan deposits. Generally poorly permeable but transmits water to underlying formations.
Qal	Alluvium	Pleistocene-Holocene	Includes sand, gravel, and clay in the eastern and southern parts of Butte Valley; poorly sorted alluvial deposits collected in relatively shallow basins or depressions; local playa deposits; and gravel and sand in major stream channels. Moderately permeable.
Ql	Lake deposits	Pleistocene-Holocene	Semiconsolidated clay, volcanic ash, diatomite, and sand with local stringers of gravelly sand. Locally interfingers with and is overlain by talus, alluvium, and alluvial-fan deposits. In general poorly permeable but moderately permeable along the east side of Butte Valley.
Qt	Talus	Pleistocene-Holocene	Wedge-shaped deposits of blocky debris at the base of steep fault scarps. Highly permeable. May contribute to groundwater recharge. May act as groundwater storage reservoir or drain.
Qfo	Fluvioglacial deposits	Pleistocene	Poorly sorted rounded to angular rock fragments, boulders, sand, clay, and silt.
Qm	Glacial moraines	Pleistocene	Unstratified bouldery deposits in a clayey matrix.
Td	Diatomite	Pliocene	Massive-appearing gray to white diatomite. Locally contains interbedded sand, cindery tuff-breccia, and volcanic ash.
Qv1	Younger volcanic rocks of the ”High Cascades”	Pleistocene-Holocene	Highly permeable and important as recharge media. Hypershene-rich andesitic flos of Deer Mountain.
Qv2	Younger volcanic rocks of the ”High Cascades”	Pleistocene-Holocene	Highly permeable and important as recharge media. Black vesicular olivine-augite basalt flows from Little Deer Mountain.
Qv3	Younger volcanic rocks of the ”High Cascades”	Pleistocene-Holocene	Highly permeable and important as recharge media. Black vesicular olivine basalt in Butte Creek Canyon.
Qb	Butte Valley basalt	Pleistocene-Holocene	Grey vesicular olivine basalt that is highly permeable.
Qbs	Basaltic flows near Sharp Mountain	Pleistocene-Holocene	Dark-colored olivine basalt that is highly permeable.

Continued on next page

Table 1.3: Geology Map Unit Descriptions (Wood 1960).

Unit Name	General Lithology	Age	Description
Qp	Pyroclastic rocks	Pleistocene-Holocene	Well-consolidated massive to thin-bedded lapilli tuff, and tuff-breccia. It is moderately permeable.
QTb1	Basaltic lava flows	Pliocene-Pleistocene	Generally very permeable and important for groundwater recharge. Grey vesicular olivine basalt flows on Big and Little Tablelands and extensive basalt flows south of Klamath Lake.
QTb2	Basaltic lava flows	Pliocene-Pleistocene	Generally very permeable and important for groundwater recharge. Coarsely vesicular black aphantic basalt near Sheep Mountain.
QTb	Older volcanic rocks of the ”High Cascades”	Pliocene-Pleistocene	Pale-grey olivine basalt and basaltic andesite and discontinous layers of yellowish tuff and tuff-breccia. Very permeable and an important groundwater storage reservoir.
QTcc	Cinder-cone deposits	Pliocene-Pleistocene	Red, brown, and black scoria mounds and cinder cones composed chiefly of andesitic and basaltic ejecta of Pliocene age and younger. Very permeable and largely unsaturated.
~~	Erosional or non-depositional surface	Miocene-Pliocene	Major Unconformity
Tvw	Volcanic rocks of the ”Western Cascades”	Eocene-Miocene	Chiefly andesitic lava flows and lesser amounts of andesitic tuff-breccia and lapilli tuff.

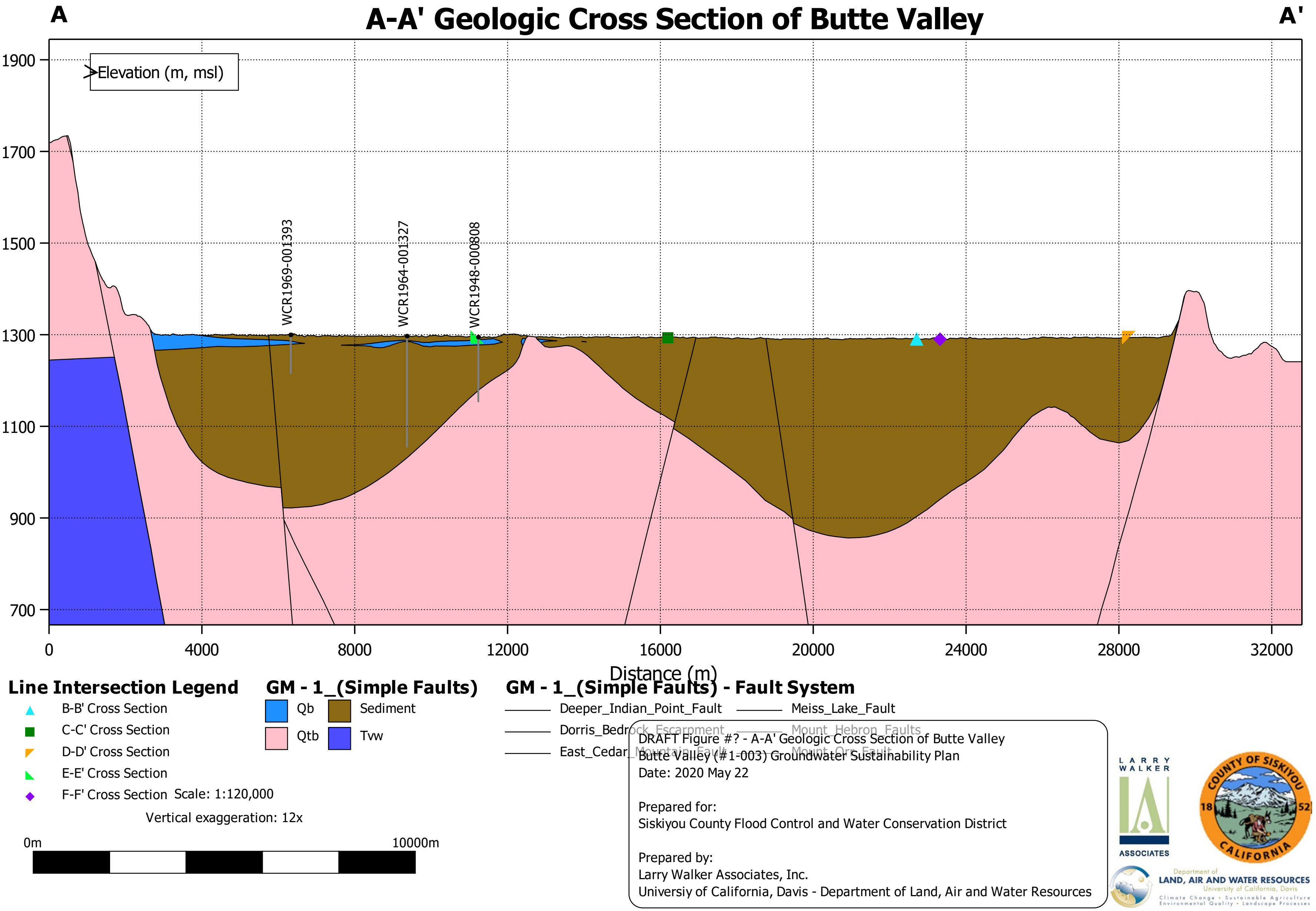


Figure 1.14: Cross Section A-A' crosses Butte Valley from the southwest to the northeast corner, shown in the geology map.

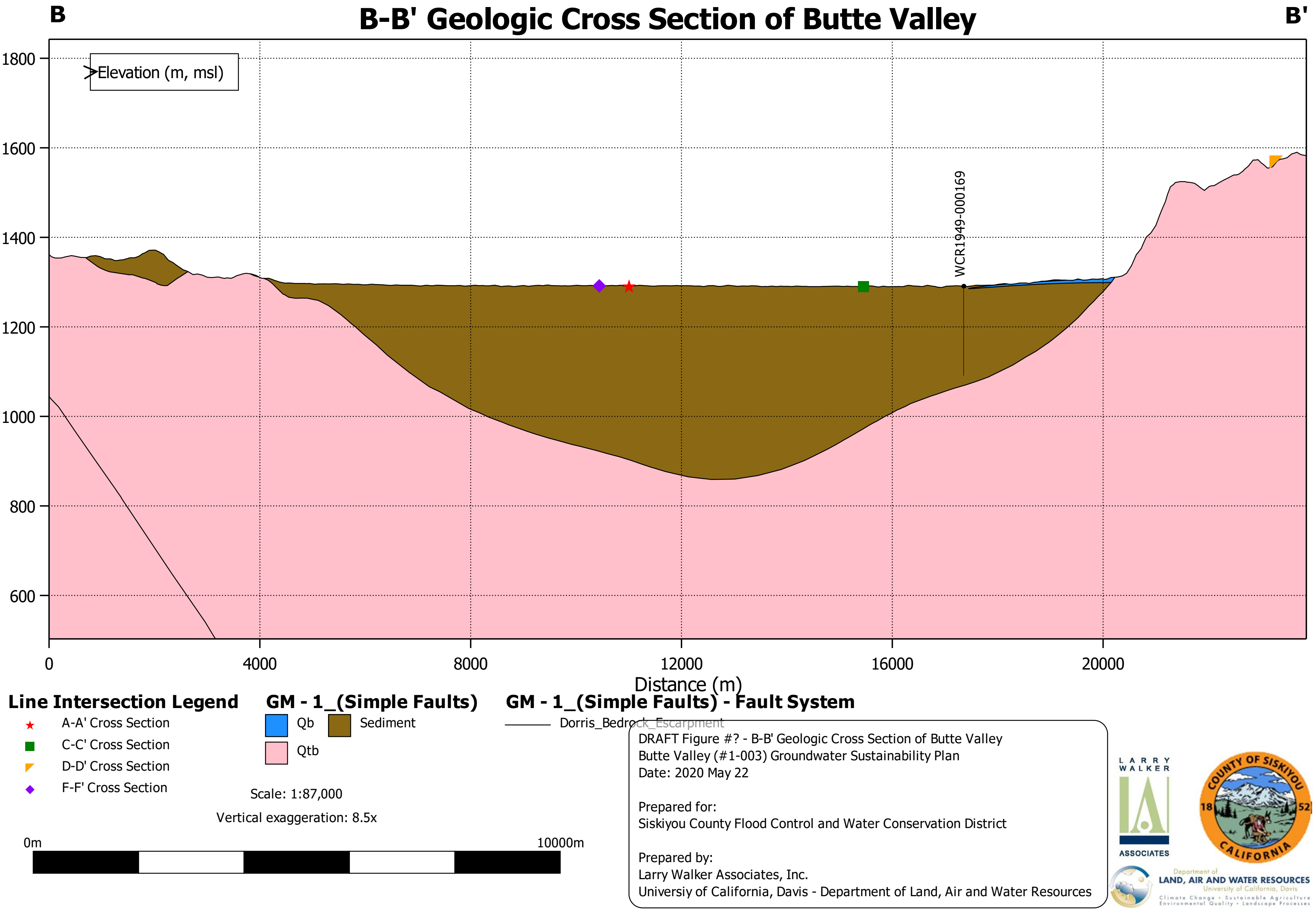


Figure 1.15: Cross Section B-B’ crosses Butte Valley from north to south near Dorris, shown in the geology map.

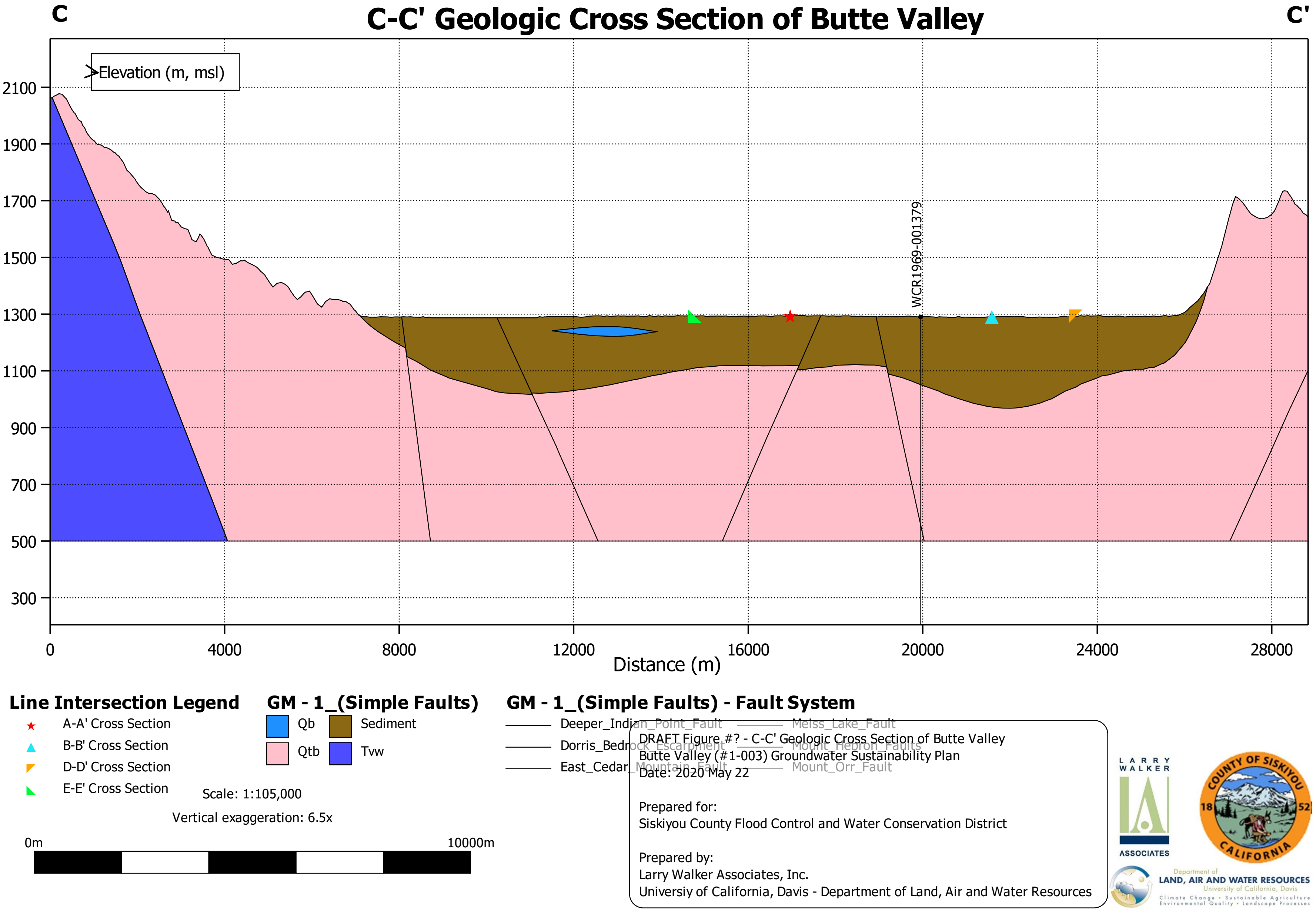


Figure 1.16: Cross Section C-C' crosses Butte Valley from the west to east, shown in the geology map.

Western Cascades Subprovince

The upper Klamath Basin has been volcanically active for at least 35 million years with two subprovinces directly underlying Butte Valley: the Western Cascades subprovince and High Cascade subprovince (Gannett, Wagner, and Lite Jr. 2012). In Butte Valley, the oldest geologic unit with surface exposure is the volcanic rocks of the Western Cascades (Tv and Tvp in Figure 1.13). Western Cascades rocks are 20-33 million years old and can be up to 20,000 ft (6,096 m) thick with primarily early to middle Tertiary lava flows, andesitic mudflows, tuffaceous sedimentary rocks, and vent deposits (Gannett, Wagner, and Lite Jr. 2012). Near Butte Valley the unit is primarily andesite and andesitic tuff breccias (DOI 1980). In general, Western Cascade deposits have low permeability due to devitrified (changed to clays and other minerals) tuffaceous materials and weathered lava flows with abundant secondary minerals. Low permeability limits the flow of groundwater through the Western Cascade unit and acts as a barrier to regional groundwater flow. The unit dips to the east and defines the lower boundary of the regional groundwater flow where present (Gannett, Wagner, and Lite Jr. 2012). This formation has not been penetrated by Butte Valley wells (DOI 1980). The unknown depth to the Western Cascades Subprovince precludes its appearance in the cross-sections.

High Cascade Subprovince

The High Cascade subprovince unconformably overlies the Western Cascade unit, with ages from the late Miocene to late Pleistocene (5.3-0.012 Ma) (Gannett, Wagner, and Lite Jr. 2012). Deposits within the upper Klamath Basin are constructional features such as volcanic vents and lava flows with relatively minor interbedded volcaniclastic and sedimentary deposits (Gannett, Wagner, and Lite Jr. 2012). High Cascade deposits in Butte Valley include Pliocene volcanic rocks and Pliocene cinder cone deposits (Wood 1960). Within the Valley, the depth to the High Cascade Volcanics confined water bearing formation varies from 47 to 1,317 feet bgs (Novick 1996).

A 1977 seismic refraction survey attempted to find the depth and structural configuration of the High Cascade Volcanics water bearing formation (DOI 1980). The survey may have detected the contact between the High Cascade Volcanics and underlying Western Cascade Volcanics or a transition to a more massive part of the High Cascades Series (DOI 1980). The survey found that faulting through the High Cascades Volcanics has made the top of the unit very irregular and the depth to the unit can locally vary hundreds of feet between nearby wells (DOI 1980). The surface of the High Cascade unit generally dips to the east, likely related to the fault system uplifting Mahogany Mountain (DOI 1980). Cross-sections A-A’ and C-C’ show that the top of the High Cascade Subprovince (Unit Qtb) is irregular and generally deepens toward the east (Figure 1.14 and Figure 1.16).

Butte Valley Basalt and Other Small Basalt Flows

All surface exposures of basaltic flows in Butte Valley and south of the Basin are important for groundwater recharge. Deposited in the late Pleistocene or Holocene, Butte Valley Basalt is a highly permeable uniform sheet of vesicular basalt that overlies and interfingers with lakebed deposits (DWR 2004). Surface exposures are in the southern part of the Valley and likely extend into the subsurface under the valley floor lake deposits through Macdoel and Meiss Lake, the southern valley floor and west of Inlow Butte (Wood 1960). The extent of the Butte Valley Basalt is shown in Figure B.2 in Appendix 2-A.

The depth of the Butte Valley Basalt varies from 0 to 110 feet bgs (Novick 1996). The basalt ranges in thickness to 80 ft (24 m), averaging approximately 40 ft (12 m) (Figure 1.14 and Figure 1.15). The subsurface extent is estimated to be 27 sq mi (70 sq km). The fractured basalt is commonly rough, broken, cavernous, and scoriaceous at contacts between relatively thin flow units. The basalt is predominantly located in the southern and southeastern region of the Valley at depths of less than 150 ft (46 m) (DWR 2004). Other small basalt flows in Butte Valley include the very permeable Pleistocene lava flows near Sheep Mountain (Wood 1960).

Pyroclastic Rocks

Pyroclastic rocks in Butte Valley are typically well consolidated, massive to thin-bedded lapilli tuffs and cindery tuff breccias that are generally cross-bedded and include abundant fragments of basalt and scoria. The deposits underlie a region located east and southeast of Macdoel ranging up to 400 ft (122 m) in thickness near Juniper Knoll. These deposits rest upon lake deposits and are partially overlapped by Butte Valley basalt (Wood 1960; County of Siskiyou 1996).

Lake Deposits

During 1.8 million years of the Quaternary Period, times of decreased temperature and increased precipitation created lakes in many hydrologically-closed drainage basins in the Western United States, such as Lakes Bonneville and Lahontan in the Great Basin (King 1994). The maximum size of the Quaternary paleolake in Butte Valley was 73 sq mi (189 sq km) with a maximum depth of 46 ft (14 m) (King 1994). This maximum extent created a shoreline terrace at 4,268 ft (1,301 m) amsl elevation around the valley rim (King 1994). The 4,268 ft (1,301 m) amsl terrace is the best developed shoreline terrace in Butte Valley and is at its widest on the north and east valley rims, particularly near Picard Cemetery on Mud Lake Ridge and just east of Dorris (King 1994). Compared to other Quaternary paleolakes, the Butte Valley 4,268 ft (1,301 m) amsl terrace is underdeveloped, suggesting that the paleolake maximum was short-lived (King 1994). While at this maximum extent, the paleolake overflowed into Rock Creek, a tributary of the Klamath River, through Sam's Neck (King 1994). This overflow may have been brief due to the lack of a distinct overflow channel connecting the Sam's Neck notch at 4,265-4,268 ft (1,300–1,301 m) amsl to the Rock Creek channel (King 1994). However hard bedrock at the channel site may have resisted erosion of a deeply-cut overflow channel and therefore, lake overflow may have lasted over a longer period (King 1994). Concurrently, Butte Creek may have deposited deltaic sediments at the 4,268 ft (1,301 m) amsl shoreline (King 1994).

The lack of well-developed shorelines at the Butte Valley rim suggests that the paleolake was mostly confined to the valley floor (King 1994). However, shoreline terraces in Butte Valley have been highly disturbed by human activity, including disturbances from the construction of houses, buildings, and roads on top of existing terraces (King 1994). Other weak paleolake shorelines occur at 4,262 ft (1299 m) and 4,255 ft (1297 m) amsl (King 1994). An example of the 4,262 ft (1299 m) amsl terrace is located at the end of Indian Point, where it is 33 ft (10 m) wide and consists of coarse beach sand with scattered angular talus boulders (King 1994). An example of the 4,255 ft (1297 m) amsl terrace is located on the west side of Cedar Point (King 1994). Below 4,255 ft (1297 m) amsl is the shallow sloping valley floor, where any further paloelake shorelines may have been destroyed by agricultural activity or never formed due to a rapid reduction in lake size to modern levels (King 1994).

Based on core samples, where lake deposits can exceed 900 feet (300 meters) in thickness, Butte Valley has been the site of a lake for between 1 and 3 million years (Carter 1994; Mathias 2014)

(Figure 1.14, Figure 1.15, and Figure 1.16). Based on sediment accumulation rates, shallow sediments appear to accumulate at a rate of 8.3 cm per thousand years to a depth of approximately 78 meters. Below 78 meters below ground surface, corresponding with approximately 930,000 years in age, sediment accumulation rates decrease to 0.9 cm per thousand years (Roberts, Verosub, and Adam 1996). Quaternary pyroclastic deposits in older lake deposits show evidence of being laid down in lake water (King 1994). At the end of the Pleistocene, the Butte Valley paleolake may have experienced rapid desiccation after the end of the last glacial cycle, reducing the lake size to the current Meiss Lake (King 1994). Quaternary paleolakes in the Great Basin also have evidence of a rapid desiccation after the end of the last glacial cycle, about 10-12,000 years ago (King 1994). A rapid desiccation reducing lake size could explain the gap in lake shorelines from 4,255 ft (1297 m) amsl elevation to 4,236 ft (1291 m) amsl (King 1994).

The rapid desiccation of the Butte Valley paleolake created an environment of playas and phytogenic dunes. Much of the original valley floor has been disturbed by human activity, particularly by the leveling of fields (King 1994). A large remnant east of Meiss Lake has never been cultivated and highly resembles a playa surface (King 1994). In the 1950s, the United States Geological Survey (USGS) mapped two small playas on the southeastern side of the Valley before the area was converted to agricultural fields (King 1994). In some locations between Meiss Lake and Dorris, phytogenic dune ridges trend northwest/southeast in parallel with area faulting (King 1994). These phytogenic dunes likely formed through increased scrub vegetation along fault fissures in the lakebed, where increased moisture can occur (King 1994).

Alluvial Fan Deposits

Isolated remnants of alluvial fan deposits are located on the west side of Butte Valley (DWR 2004). Alluvial fan deposits in Butte Valley are saturated, but poorly permeable with groundwater yields suitable for stock or domestic wells (DOI 1980).

In Butte Valley, these deposits were deposited during the Pleistocene to the Present and are composed of poorly-sorted volcanic rock debris, rounded cobbles of volcanic origin, gravel, sand, and clay from the Cascade Range (DOI 1980; DWR 2004). The deposits are coarse near the mountain fronts and grade into fine materials in the lower part of the fans. The fans interfinger with lake deposits at depth. The deposits have low permeability except where well-sorted gravel lenses are encountered and generally yield small quantities of water to wells. Thickness of the deposits range up to 350 ft (107 m) (DWR 2004).

Alluvium

In Butte Valley, alluvium deposits were deposited from the Pleistocene to Recent and are moderately permeable but generally above the water table. Within the Valley alluvium deposits include several different types (Wood 1960):

- Sand, gravel, and clay in the eastern and southern parts of Butte Valley.
- Poorly-sorted alluvial deposits in relatively shallow basins or depressions.
- Local playa deposits.
- Gravel and sand in major stream channels.

Alluvium in the northern Butte Valley was deposited by sheetfloods, slope wash, and other agents of erosion. Deposits on the eastern border are mainly fine to coarse-grained sand of volcanic origin, with perhaps lakeshore or beach deposits. They were deposited by sheetfloods, slope wash, rill wash, and other colluvial processes. Some alluvium has been redeposited as windblown or dune sand mantling parts of the steep fault scarps (Wood 1960).

In the south, sand and gravel alluvium deposits unconformably overlie the Butte Valley basalt and overlie and locally interfinger with the lake deposits (Wood 1960; DOI 1980). They are characterized by lenticular deposits of clay, silt and sand (DOI 1980). The deposits are generally poorly permeable and can yield water for stock or domestic wells (DOI 1980). Along the valley margin, the alluvial deposits range from 0-60 ft (0-18 m) in thickness. Volcanic sand and gravel alluvium in the southwest of Butte Valley was likely deposited by Butte Creek flood waters and may represent a delta built by the creek during the high stages of the lake that formerly filled the Valley. Dune sand near Macdoel is wind reworked volcanic sand that is currently being leveled and cultivated (Wood 1960).

Playa deposits are common in the Butte Valley region, with clay, silt, and minor amounts of sand. They occur in the topographically lowest areas of small enclosed basins and merge laterally into alluvial slope deposits. They have low permeability and likely have highly saline water (Wood 1960).

Other alluvium deposits are poorly sorted and unconsolidated gravel, sand, and silt. They stem from the decomposition and erosion of volcanic material in adjacent mountainous areas and were deposited in basins and depressions by streams, sheetfloods, slope wash, and other erosional processes (Wood 1960).

Talus

Talus in Butte Valley are highly permeably wedge-shaped deposits of blocky debris at the base of steep fault scarps on the north and east sides of the Valley (Wood 1960). Talus deposits generally act as groundwater conduits and drains and may act as groundwater storage reservoirs where interfingered with saturated sediments (DOI 1980). Water bearing properties are unknown and the few wells that penetrate talus deposits likely draw groundwater from both the talus sediments and other interconnected aquifer subunits (DOI 1980).

The deposits are unsorted, uncemented, angular blocks, boulders, and fragments of volcanic rocks of a few inches to greater than 6 ft (1.8 m) (Wood 1960). In some areas, the gaps between coarse materials have been filled by sand. In Butte Valley, large talus deposits primarily occur on the east margin, near the City of Dorris down to Sheep Mountain. In some areas the talus deposits are concealed underneath and likely interfinger alluvial and land-bed deposits. On westward-facing scarps, talus deposits are covered by windblown sand. The thickness and lateral extent of the talus deposits is not well defined, though two wells near Dorris encountered 143 and 360 ft (44 and 110 m) of talus (Wood 1960).

Dune Sand

A very young deposit generally above the water table, a large dune sand deposit sits on the eastern border of Butte Valley, west and north of Inlow Butte and south of Cedar Point (Wood 1960; King 1994). Dune sand deposits too small to plot on a geologic map exist elsewhere in Butte Valley. Dune sand covers High Cascade rock outcrops in westward-facing escarpments along the Butte Valley border (Wood 1960).

The deposit is unconsolidated, fine-to-coarse, massive, loosely compacted, crossbedded quartz sand that is in part actively drifting and up to 20 ft thick. The dune sand was reworked from lake and alluvial deposits which have migrated eastward and northward from old abandoned lake shorelines. Dunes have largely been stabilized by a sparse cover of vegetation, but some sections have dunes actively advancing upon older dunes, talus and High Cascades rock outcrops (Wood 1960). The majority of the extensive aeolian dune deposits south of Cedar Point were likely produced by wave action on the eastern shorelines of the Quaternary Butte Valley paleolake (King 1994).

2.2.1.5 Faults

Beginning in the Pleistocene (2.6-0.012 Ma), faulting began to form Butte Valley and remain active today (DOI 1980). Butte Valley is bordered on all sides by the Cedar Mountain fault system, a complex group of generally north- to north-northwest-striking normal faults along the boundary between the Cascade Ranges and the Modoc Plateau (W. A. Bryant 2000). Fault displacement is nearly vertical and ranges from a few feet to possibly more than several thousand feet along major faults (DOI 1980). The fault system has offset the latest Pleistocene and Holocene volcanic rocks, glacial, and alluvial deposits (Williams, 1949; Wood, 1960; Bryant, 1990, Bryant 2000). Historic surface fault rupture is associated with the local magnitude (ML; Richter magnitude) 4.6 Stephens Pass earthquake of August 1, 1978 (Bennett, 1979)(W. A. Bryant 2000). An earthquake in late June of 1966 shook the Dorris area and ruptured the clay lining of a waste effluent evaporative treatment pond about 0.5 mi (0.8 m) southwest of Dorris (DWR 1968; DOI 1980). The faults near Dorris exhibit evidence of continuing into the bedrock below the valley floor (DWR 1968).

Five sections of the Cedar Mountain fault system exist within Butte Valley: Cedar Mountain, Mahogany Mountain, Mount Hebron, Meiss Lake, and Ikes Mountain Faults. The Cedar Mountain Fault Zone begins at the northern border of the Valley through the middle to the southern border (see Figure 1.13). Within Butte Valley the fault zone is 6.8 mi (11 km) wide, with numerous short, northwest-trending faults in the Valley floor and through the Butte Valley Basalt (W. A. Bryant 2000). Offset features within the Valley indicate that the fault zone has been active during the Holocene (W. A. Bryant 2000). The northwest Valley border is characterized by the Ikes Mountain Fault, a north-trending normal fault (William A. Bryant 1990; W. A. Bryant 2000). It was active in the late Quaternary with little evidence for more recent activity (William A. Bryant 1990; W. A. Bryant 2000). The Meiss Lake Fault passes through the middle of Meiss Lake and is a north-trending fault with Holocene activity (William A. Bryant 1990; W. A. Bryant 2000). Some geomorphic evidence suggests a component of right-lateral strike slip (William A. Bryant 1990; W. A. Bryant 2000). The Valley border in the southwest is defined by the Mount Hebron Fault Zone, a 4.3 mi (7 km) wide series of north to northwest-trending normal faults. Geomorphic evidence limits fault activity to the Quaternary and late Quaternary (William A. Bryant 1990; W. A. Bryant 2000). The Mahogany Mountain Fault Zone marks the northwest border of the Valley, a northwest-trending zone of normal faults with vertical displacement to the southwest (William A. Bryant 1990; W. A. Bryant 2000). Geomorphic evidence suggests that the fault has been active in the Holocene (William A. Bryant 1990; W. A. Bryant 2000).

A 1998 DWR Well Interference Investigation in the northwestern portion of the Basin indicates that local faults can act as both a flow barrier and very transmissive conduit for groundwater flow (DWR 1998). The study's conclusions suggest that other faults in the area likely influence groundwater flow in a similar fashion (DWR 1998). The aquifer performance test of the Butte Valley Wildlife Area Well 7A shows structural continuities, including (DWR 1998):

- A strong north-south hydraulic continuity along a fault trace adjacent to two monitoring wells.

- Areas on either side of a fault adjacent to Well 7A are somewhat isolated from each other, with improved hydraulic continuity within a common fault-bounded area.
- There is a hydraulic connection in talus deposits along a fault trace.
- Well 7A has an asymmetrical cone of depression, attenuated on the east side of the fault trace.

Faults in the Basin support the formation of springs, where numerous Basin springs align with faults (DWR 1998). Faults can impede groundwater flow and cause a buildup of groundwater, which can emerge at the surface in the form of a spring (DWR 1998). Local agriculture in the Basin can be supported by springs, such as Holzhauser Ranch in Sam's Neck, where water from two springs are collected into ponds for irrigation (DWR 1998).

2.2.1.6 Water Bearing Formations

Water bearing formations within the Basin aquifer are described in the following discussion, where the principal water bearing formations are Lake Deposits, Butte Valley Basalt, and High Cascade Volcanics, and minor formations are Alluvial Fan Deposits and Pyroclastic Rocks (DWR 1998; DWR 2004). Unconfined formations include the Lake Deposits, Pyroclastic Rocks, and the Butte Valley Basalt (DOI 1980). Within the Basin the Lake Deposits cover the High Cascade Volcanics and Butte Valley Basalt, confining the two formations in most areas (DWR 1998). The Butte Valley Basalt can also be locally confined when overlain by fine-grained alluvium with low permeability (DOI 1980). Comparatively, the High Cascade Volcanics and Butte Valley Basalt have high yields and the Lake Deposits have relatively low yields (DWR 1998).

Groundwater flow and distribution in the Basin is controlled by localized faulting, aquifer material variability, and the interconnection of formation units, which can enhance, diminish, or block flow (DWR 1998). Faults and fractures can act as either groundwater conduits or barriers to flow (DWR 1998). Faults in Butte Valley may act as vertical paths of high permeability locally connecting the Lake Deposits and High Cascade Volcanics water bearing formations (DWR 1968). Faults can also offset formations and juxtapose more permeable formations against less permeable units (DWR 1998). There is limited vertical hydraulic continuity between the low, variably permeable Lake Deposits and high isotropic permeable High Cascade Volcanics due to the contrasting permeability (DWR 1968; DWR 1998). The High Cascade Volcanics water bearing formation is confined and separate from the Lake Deposits near Dorris (DWR 1968), and Meiss Lake (DWR 1998).

High Cascade Volcanics Water Bearing Formation

The High Cascade Volcanics water bearing formation is highly fractured, very permeable, highly transmissive, and an important regional groundwater source (DWR 1998; DWR 2004). The High Cascade Volcanics is divided into a series of "compartments" by fine-grained feeder dikes radiating out from parent cones and by a series of northwest-trending faults (Novick 1996). Wells are routinely developed into this geologic unit and water yields range from 700 to 5,000 gpm, but often produce over 3,000 gpm (Novick 1996; DWR 2004). Groundwater within the unit is usually confined by Lake Deposits and some irrigation wells have artesian flows (Novick 1996; DWR 2004). Most wells in Butte Valley encounter the formation at depths between 240-600 ft, with some wells intercepting the formation at shallow depths of 47 ft or deep depths of 1,317 ft (Novick 1996). Springs stemming from the High Cascade Volcanics supply the perennial flows for Prather, Muskgrave, Harris, and Ikes Creeks (Novick 1996). This water bearing formation has not experienced overdraft (Novick 1996).

Beyond being a major element of the Basin's groundwater storage reservoir, the High Cascade Volcanics is also very important for groundwater recharge (DWR 2004). It has a large areal extent beyond the Basin margin and acts as an intake media for groundwater recharge into the Basin (DWR 2004). It defines the Basin boundaries in the west, north, and east and underlies the lake bed deposits (Wood 1960; DWR 2004).

The High Cascade Volcanics consist of successive sheets of basalt, basaltic andesite, discontinuous layers of massive basaltic tuff and tuff breccia, and some isolated lapilli tuff, and cinder-cone deposits (DWR 2004). The individual flow units range in thickness from 10- to 50-ft (3–15 m) and intermittently up to 100 ft (30 m) (DWR 2004). Individual well yields are highly dependent on the flow thickness and number of flow contacts intercepted, as well as vertical fracturing (DOI 1980; DWR 2004). Tuffaceous deposits are essentially non-water-bearing except for fracture zones and intercalated basaltic flows (DWR 2004).

Butte Valley Basalt Water Bearing Formation

Historically the Butte Valley Basalt has been the primary groundwater-producing water bearing formation in the southern part of the Basin (DWR 1998). The unit is also the most productive formation in the region, with water yields of 1,000 to 4,000 gpm and an average of 2,000 gpm (Novick 1996). Highly productive wells from this formation are common in the Macdoel-Mount Hebron area and can generate up to 4,000 gpm (DWR 1998; DWR 2004). Specific capacities of 100 gpm per foot of drawdown are common and values up to 1,100 gpm per foot of drawdown have been documented (DWR 2004). A temporary seasonal overdraft occurs during the latter part of the irrigation season evidenced by well interference from overutilization (USBR 1980; DWR 2004). This formation has been developed to its maximum productivity and in some years seasonal pumpage exceeds storage capacity (Novick 1996; DWR 2004). Toward the end of the irrigation season, some shallow BVID and BVWA wells go dry but recover by the following season after groundwater recharge (Novick 1996). The formation recharges annually with no long-term overdraft in average to above average precipitation years (Novick 1996).

The Butte Valley Basalt consists of a highly permeable, fractured, uniform sheet of vesicular basalt with an average thickness of 40 ft (12 m) and a range from 6 ft (1.8 m) to hundreds of feet thick (DOI 1980; DWR 1998; DWR 2004). A system of nearly vertical joints or shrinkage cracks through the unit facilitates the vertical migration of groundwater (DWR 1998). Internally, the formation consists of comparatively thin lava flows where contacts between flows are commonly rough, broken, cavernous, and scoriaceous (DWR 1998; DWR 2004). The combination of vertical and horizontal flow paths makes the Butte Valley Basalt a productive water bearing formation (DOI 1980). The basalt is predominantly located in the southern and southeastern region of the Basin at depths of less than 150 ft (46 m), overlies and interfingers with Lake Deposits, and has an estimated subsurface extent of 27 sq mi (70 sq km) (DWR 2004). The unit extends northward as far as the east side of Meiss Lake (Novick 1996). The rough broken surface exposures provide areas of recharge (DWR 2004). Butte Creek is diverted to several locations to recharge the Butte Valley Basalt (Novick 1996).

Lake Deposits Water Bearing Formation

The Lake Deposits is the most important water bearing formation on the east side of the Valley but yields less water than the Butte Valley Basalt and High Cascade Volcanics water bearing formations (Novick 1996). The water bearing formation is locally both unconfined and confined (Novick 1996). Lake Deposits can occur both above and below the Butte Valley Basalt but always above the High Cascade Volcanics (Novick 1996). The formation depth ranges from 0 to 125 ft bgs (Novick 1996). Water yields from the best wells range from 1,500 to 2,600 gpm (Novick 1996).

Lake Deposits vary widely in their ability to transmit water, but are generally more permeable and coarser grained on the east and south sides of the Valley and more permeable along the Basin margin compared to mid-basin (DOI 1980; DWR 1998; DWR 2004). Mid-basin Lake Deposits generally represent fine-grained lake deposits while the valley margins generally contain coarser, sandier near-shore deposits from the paleolake that once filled Butte Valley (DWR 1998). Along the Valley margins, Lake Deposits interlayer with volcanic rocks and can yield moderate to high groundwater yields (DWR 1998). Coarser Lake Deposits in the western and northwestern part of the basin generally yield sufficient water for stock wells, while the more sandy eastern valley margin can have yields up to 2,500 gpm (DWR 2004). At the southern Basin margin deposits are interfingered with the recharging Butte Valley Basalt and well yields can exceed 4,100 gpm (DWR 1998; DWR 2004). Lake Deposits are generally lenticular (DWR 1968).

The Lake Deposits consist of semi-consolidated deposits of relatively impermeable sand, silt, clay, ash, lenses of diatomaceous clay, and local stringers of gravelly sand (DWR 1998; DWR 2004). Unit thickness is variable from 350 to 1,300 ft (107–396 m), but generally thickens to the west and unconformably overlies the older volcanic rocks of the High Cascades (DOI 1980; DWR 2004). In the central Basin, a calcium carbonate cemented clay hardpan soil is usually present from six inches to several feet beneath most soils and is particularly close to the surface around Meiss Lake (County of Siskiyou 1996; DWR 2004). The hardpan impedes vertical groundwater recharge into the Lake Deposits water bearing formation (DWR 1998).

Sand deposits in the Lake Deposits exhibit a general grain size and thickness gradation from south to north, suggesting the presence of a major stream entering the paleolake from the south, with coarser material dropping out of suspension first in the south and the finer material being carried and deposited north and west (DOI 1980). In the south, coarse-grained lake deposits are interfingered with and underlie the Butte Valley Basalt (DOI 1980).

West of U.S. Highway 97, Lake Deposits on the west and northwest valley sides are generally fine-grained silts and clays of very low permeability that commonly serve as confining layers (DOI 1980; DWR 2004). Though saturated with groundwater these fine-grained lake deposits yield only small quantities of water to stock wells (DOI 1980).

East of U.S. Highway 97, Lake Deposits are loose, fine to medium-grained bedded sands interbedded with clay (DWR 2004). East of U.S. Highway 97, northeast of Juniper Knoll and in the southern part of the Valley, lenses and beds of sands and gravels over 300 ft (91 m) thick are interbedded with and overlie finer-grained clays and silts (DOI 1980). East of U.S Highway 97, northeast of Juniper Knoll and the east side of the Valley, the lake deposits are loose, fine to medium-grained, current-bedded sands interbedded with clay (DOI 1980). To the north, the thickness and number of sand lenses generally diminish and the grain size decreases (DOI 1980). Near Dorris are discontinuous lenses of fine to medium sand that yield water to mainly domestic or low-yielding irrigation wells (DOI 1980). In the eastern half of the Basin, specific capacities range from 9 to 62 gpm per foot of drawdown (DWR 2004). Locally, and along the eastside Basin margin, specifically sandy lake deposits can interfinger with highly permeable deposits of beach sand and talus debris (DWR 2004).

South of Macdoel, the sand layers thicken and the grain size increases (DOI 1980). The coarse-grained lake deposits in the south are moderately to highly permeable with loose sands and gravels that yield water freely but cause problems with well drilling and completion (DOI 1980). Wells in these lake deposits often report "sanding up" problems and can have issues with caving (DOI 1980).

Alluvial Fan Deposits Water Bearing Formation

Isolated remnants of alluvial fan deposits are located on the west side of Butte Valley. These deposits are composed of poorly-sorted volcanic rock debris, cobbles, gravel, sand, and clay from the Cascade Range. The deposits are coarse near the mountain fronts and grade into fine materials in the lower part of the fans. The fans interfinger with Lake Deposits at depth. The deposits have low permeability except where well-sorted gravel lenses are encountered and generally yield small quantities of water to wells. Thickness of the deposits range up to 350 ft (107 m) (DWR 2004).

Pyroclastic Rocks Water Bearing Formation

The deposits underlie a region located east and southeast of Macdoel ranging up to 400 ft (122 m) in thickness near Juniper Knoll (Wood 1960; DWR 2004). Deposits are exposed on the surface over a large area east of Macdoel (DOI 1980). The unit is moderately to highly permeable and will yield water freely to wells where it is saturated (DOI 1980). Most of the outcrop lies above the saturated zone, where it acts as an intake area for groundwater recharge (Wood 1960; DOI 1980). These rocks have largely been developed for stock wells (DWR 2004).

The Pyroclastic Rocks unit is characterized by well-consolidated, massive to thin-bedded lapilli tuffs and cindery tuff breccias that are generally cross-bedded and include abundant fragments of basalt and scoria (DWR 2004). Deposits were created via at least two widely separated eruptive events (DOI 1980). The deposit overlies the lake deposits (DOI 1980; DWR 2004). The Butte Valley Basalt was deposited between the two main pyroclastic events and locally overlaps and is interbedded with the pyroclastic deposit (DOI 1980; DWR 2004).

2.2.1.7 Groundwater Recharge

Natural recharge occurs primarily from the infiltration of precipitation, underflow from the Basin-adjacent volcanic rocks (on the north, west and south margins) and streamflow losses (DWR 2004). Surface exposures of Butte Valley Basalt, High Cascade Volcanics, and Pyroclastic Rocks within the watershed are sources of recharge from rain and snow (Novick 1996; DWR 2004). The High Cascade Volcanics recharges via snow pack in the north, west, and south sides of the watershed (Novick 1996). Lake Deposits also contain sources of groundwater recharge where volcanic talus deposits occur along fault scarps that cut into deeper water bearing formations (DWR 1998). Groundwater recharge via streamflow losses are provided by Butte, Antelope, Prather, Ikes, Harris and Muskgrave Creeks (Novick 1996). In the southern part of the Basin, seepage losses from unlined canals along the western fringe and deep percolation from irrigation also contribute to recharge (DWR 2004). The wetlands and canals in BVWA also recharge the groundwater (Novick 1996).

2.2.1.8 Soil Characteristics

Soils in Butte Valley have developed in the valleys, basins, foothills, and mountain slopes, with distinct characteristics in each location. The following discussion references map units, named for major soil components, in the U.S. Department of Agriculture (USDA) 1994 Soil Survey of Butte Valley-Tule Lake Area (USDA 1994). A map of soil orders in the watershed is shown in Figure 1.17. The general soil units discussed below are shown in Figure 1.18. The infiltration and runoff potential as defined in hydrologic soil groups is shown in Figure 1.19. In Butte Valley, areas of poor soil permeability have an accumulation of salt and alkali, and tend to occur in areas with a hardpan (1996 Siskiyou County). Soils in the center of the Valley and bench lands along the northern valley rim have a prominent heavy calcareous hardpan (DOI 1980). In adjacent cropland, fields are leached through deep canals to decrease salts and alkali, and the hardpan is ripped periodically to improve rooting depth and drainage (1996 Siskiyou County).

Most soils in Butte Valley are derived from lacustrine deposits, from the paleolake that used to fill the Valley (DOI 1980). The center of the Valley, from the lowest elevation at Meiss Lake to the eastern valley side, is slightly lower than the north and south valley areas. The center of the Valley has historically acted as an evaporation basin for the spring runoff (DOI 1980).

Valley Floor Soils

The Butte Valley floor contains several soil orders: Ultisols in the middle of the Valley, Mollisols at the Valley edges, and Inceptisols and Vertisols west of Meiss Lake. The valley floor is further divided into several general soil units, which are broad areas that have a distinctive pattern of soils, relief, and drainage. While each soil subunit is a unique natural landscape, the general soil units can be used for general land uses and broad interpretive purposes (USDA 1994).

The Inlow-Ocho soil unit is centered in the Butte Valley National Grasslands and extends southwest to Meiss Lake and crosses U.S. Highway 97 towards Inlow Butte. It is a silt to very fine sandy loam that forms on lake terraces. The unit formed from lacustrine sediment and alluvium derived from volcanic ash and extrusive igneous rock. It is moderately deep to shallow, moderately well drained to somewhat poorly drained, with slopes of 0-2%. Below the subsoil is a hardpan at about 18-33 in (0.46–0.84 m) below the surface. Below the hardpan is loamy sand. Minor components of this soil include well-drained loamy Modoc soils, with a subsoil of loam and sandy clay loam, and shallow, poorly-drained Ocho Variant soils, with a subsoil of clay (USDA 1994). The soil unit is mainly used as rangeland. Hazards of the Inlow soils include soil blowing and sodicity, while the Ocho soils have issues with sodicity, a shallow effective rooting depth, surface crusting, and ponding. Soil hazards limit the production of forage and make seeding unfeasible. The moderate hazard of soil blowing requires onsite investigation prior to mechanical treatment. The sodicity hazard is deemed unfeasible to overcome (USDA 1994).

The agricultural land in Butte Valley is predominantly underlaid by Mollisols. Mollisols on the north half of Butte Valley are characterized by the Modoc-Rojo soil unit. The soil unit forms on lake terraces and was created in alluvium and lacustrine sediment derived from extrusive igneous rock and material weathered from tuff and volcanic ash. The loamy soil is moderately deep, with slopes from nearly level to moderately sloping (0-9% slope). The surface layer is loam to sandy loam and the subsoil is loam, sandy clay loam or sandy loam. A hardpan or duripan lies roughly 28-34 in (0.71-0.86 m) below the surface. Below the hardpan is sand, weathered tuff, and volcanic ash. The soil unit also has minor components of the well-drained Dehill, Dotta, Mudco, and Truax soils and the moderately well-drained Medord, Doel, and Rangee Variant soils. Dehill, Dotta, Medford,

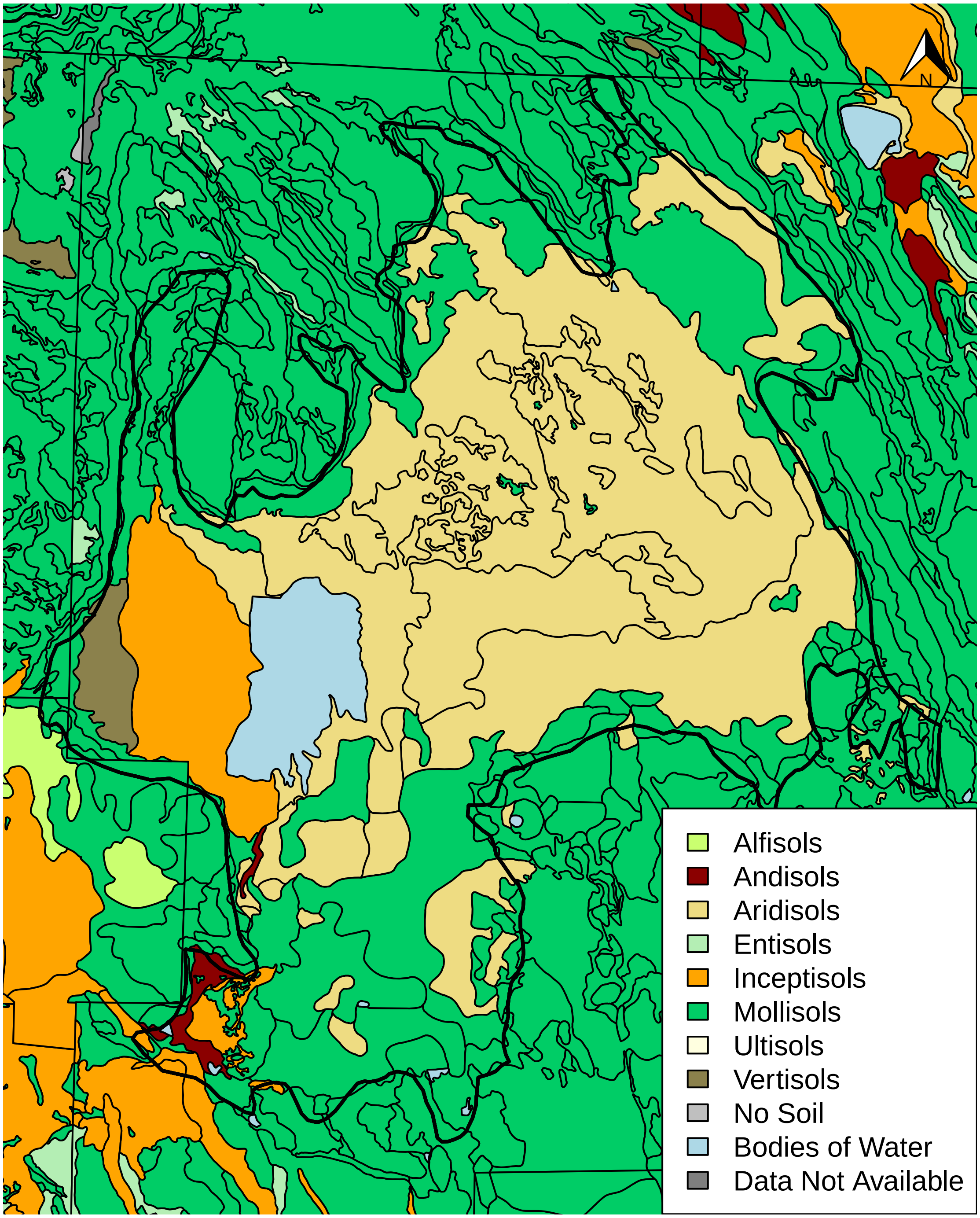


Figure 1.17: Soil classifications in Butte Valley

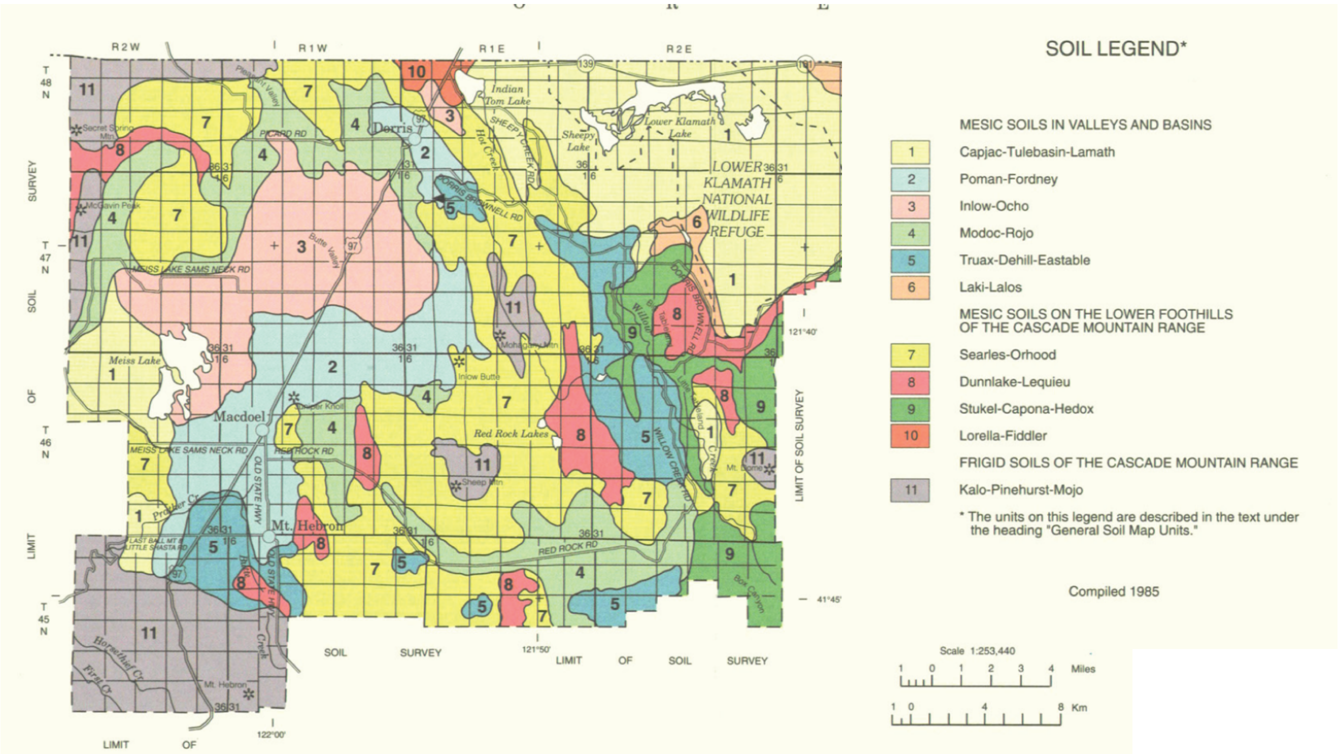


Figure 1.18: General Soil Map of Butte Valley from the 1994 USDA Soil Survey of the Butte Valley-Tule Lake Area. Modified from the original 1994 USDA General Soil Map, included in Appendix 2-A.

and Traux soils are deep soils at higher elevations with no duripan. Mudco and Rangee Variant soils have a duripan within 20 in (0.51 m) of the surface. Doel soils have a surface layer underlain by sand. The Mullisol Modoc-Rojo soil unit is used for cultivated crops, hay and pasture, and rangeland. Hazards include soil blowing, hardpan depth, low available water capacity, and frost potential. The depth to volcanic tuff in the Rojo soils discourages ripping. A temporary water table above the hardpan can be prevented with good irrigation management (USDA 1994).

Agricultural activity in the southern half of Butte Valley is predominantly underlain by the soil unit Poman-Fordney, whose subunits are classified as either an Ultisol or Mollisol. This unit also surrounds Dorris. The sandy soils lie on alluvial plains and terraces and were formed from volcanic tuff and other kinds of extrusive igneous rock. It is moderately deep to very deep and nearly level to strongly sloping (0-15% slope). The surface layer is loamy sand. The substratum of the very deep, excessively drained Fordney soils is loamy sand. The moderately deep and somewhat excessively drained Poman soils have a subsoil of loamy sand above a duripan at about 29 in (0.74 m) below the surface. Underlying the duripan is sand. Minor components of the soil unit are the well-drained Dehill soils, the moderately well-drained Doel soils and the somewhat poorly-drained Podus and Poe soils. Dehill soils are sandy loams at higher elevations. Podus soils have a duripan at 10-20 in (0.25-0.51 m) below the surface and have a high water table. Similarly, Poe soils, too, have a high water table, but with a duripan at 20-40 in (0.51-1.0 m) below the surface. The Poman-Fordney soil unit is used for cultivated crops, hay and pasture, rangeland, and home development. Issues include a rapid rate of water intake and low available water capacity. Hazards include soil blowing and a risk for frost (USDA 1994).

The Capjac-Tulebasin-Lamath soil unit has subunits that can be classified as an Inceptisol, Vertisol

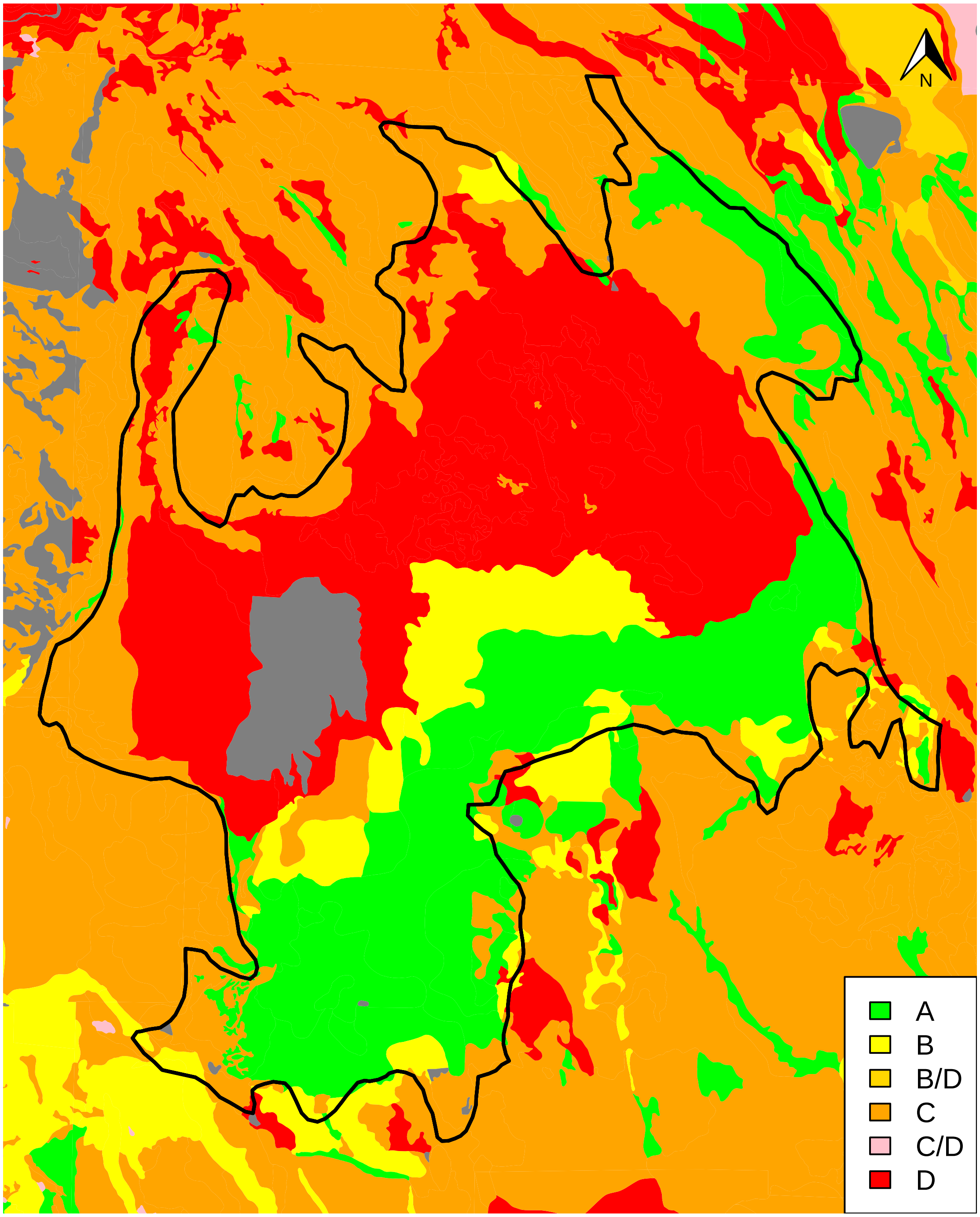


Figure 1.19: Hydrologic soil groups in Butte Valley, where Group A are soils with a high infiltration rate and low runoff potential to Group D with very slow infiltration rate and high runoff potential. Soils have two Groups if a portion is artificially drained and the rest undrained.

or Andisol. This loamy soil occurs in lake basins and forms from lacustrine sediment derived dominantly from diatomite, volcanic ash, and extrusive volcanic rock. The soil is very deep, nearly level (0 to 2% slope) and very poorly drained to poorly drained. The subunits in Butte Valley share further characteristics, where they are all very deep, artificially drained soil in lake basins, protected by dikes and levees, and have a water table controlled by pumping to deep lateral drains (USDA 1994).

The Vertisol subunit is a Pit silty clay, formed in poorly drained alluvium derived from extrusive igneous rock. Dikes and levees protect this soil from brief flooding from January through May (USDA 1994). The water table is maintained at a depth of 5-6 ft (1.5–1.8 m). It is a silty clay at 0-26 in depth, silty clay loam or clay loam at 26-31 in and silt loam at 26-31 in (0.66–0.79 m) (USDA 2020b). Permeability is low and available water capacity is high. The unit is used for cultivated crops such as wheat and barley, and rangeland. Soil issues include a high shrink-swell potential and a susceptibility to compaction (USDA 1994).

There are two pockets of Inceptisols on the eastern side of the Valley. The subunit west of Meiss Lake is a Teeters silt loam and the subunit south of Meiss Lake along Prather Creek is a Lamath silt loam. Both formed from poorly drained silty or lacustrine sediment derived from diatomite, volcanic ash, and extrusive igneous rock. Dikes and levees protect the soil from brief flooding from March through May (USDA 1994). The water table is maintained at a depth of 1.5-4 ft (0.46-1.2 m). The soil is saline. The Teeters silt loam soil unit is silt loam, with some silt at 10-60 in (0.25-1.5 m) depth. The Lamath silt loam soil unit is silt loam at 0-21 in (0-0.53 m) depth, sand and loamy sand at 21-53 in (0.53-1.3 m) depth, and stratified sand to silt loam at 21-53 in (0.53–1.3 m) depth (USDA 2020b). The diatomite and volcanic ash origin of the soil creates a very high water capacity. Soil blowing is a moderate hazard when the surface layer is dry under high wind conditions. The soil is used for cultivated crops, hay and pasture and wildlife habitat (USDA 1994).

The Andisols are Capjac silt loam, formed in poorly drained lacustrine sediment derived from diatomite and volcanic ash. Dikes and levees protect this soil from rare flooding from October through May. The water table is maintained at a depth of 1.5-3.0 ft (0.46–0.91 m). The surface layer down to about 26 in (0.66 m) depth is silt loam and the substratum down to 60 in (1.5 m) or more is slightly saline silt loam. Permeability is moderate and frost is a hazard. The diatomite and volcanic ash origin of the soil creates a very high water capacity. Soil blowing is a moderate hazard when the surface layer is dry under high wind conditions. This soil is used for wildlife habitat, cultivated crops, and irrigated hay and pasture (USDA 1994).

Alluvial Fan Soils

From U.S. Highway 97 west of Mount Hebron to the southern valley rim below the highway and Mount Hebron is the Traux-Dehill-Eastable soil unit. It is a well drained, very deep, loamy soil that forms on alluvial fans, formed dominantly in alluvium derived from volcanic tuff and extrusive igneous rock. It is nearly level to strongly sloping, with slopes of 0-15%. Traux soils are predominantly sandy loam, with sandy clay loam subsoil. Dehill soils are fine sandy loam. Eastable soils are loams with a clay loam subsoil. Minor soil units are the well drained Dotta, Hedox, and Munnell soils and the moderately well-drained Leavers soil. The general sand unit is used for cultivated crops, irrigated hay and pasture, and rangeland. Soil hazards include soil blowing and frost (USDA 1994).

Soils of the Lower Foothills of the Cascade Mountain Range

The foothills bordering Butte Valley are dominated by the Mollisol Searles-Orhood soil unit. The well drained soil forms on hills and mountains and formed in material weathered from extrusive igneous rock. The very stony or very cobbly loamy soil is moderately deep and shallow, and gently sloping to very steep (2-50% slope). The surface layer is a very stony or very cobbly loam. The upper part of the subsoil is very cobbly loam and the lower part is very cobbly clay loam and very cobbly loam. Extrusive ignous bedrock is about 16 or 28 in (0.41-0.71 m) deep. The soil unit has various minor components with variations on the main soils, such as a clayey subsoil, soils deeper than 60 in (1.5 m) deep or less than 10 in (0.25 m) deep. The soil unit also has instance of rock outcrops, with no soil cover, and areas of rubble, where 90 % or more of the surface is covered by stones and boulders (USDA 1994). The soil unit is used for rangeland and growth of western juniper. High surface slopes and general stoniness limits seeding, livestock access, and woodcutting (USDA 1994).

The Dunnlake-Lequieu soil unit occurs sparsely at the valley borders. The very stony loamy soils are shallow to very shallow, with slopes from 0-50%. The soil occurs on plateaus and mountain side slopes and formed from material weathered from extrusive igneous rock. Both Dunnlake and Lequieu soils have a very stony loam surface layer. Dunnlake soils have a clay loam upper subsoil and gravelly clay lower subsoil, with hard, extrusive igneous bedrock at about 16 in (0.41 m) depth. Lequieu soils have a 5 in (0.13 m) substratum of very cobbly loam and andesite bedrock at 8 in (0.20 m) depth. Due to the surface stoniness and depth to bedrock, the soil unit is used as rangeland (USDA 1994).

Soils of the Cascade Mountain Range

The edges of the groundwater Basin contain parts of the Kalo-Pinehurst-Mojo general unit. The stony to very stony loamy soil occurs on mountains and formed in material weathered from extrusive igneous rock. The soil is moderately deep to deep with slopes that are moderately sloping to steep (5-50% slope). The surface layer is very stony sandy loam, stony sandy loam or stony loam. The subsoil is very cobbly loam, very cobbly clay loam, gravelly loam, very stony loam, or clay loam. Extrusive igneous bedrock occurs between 27-55 in (0.69-1.4 m) depth. The soil unit is used as woodland, with some livestock grazing.

2.2.1.9 Surface Water Bodies

Surface water bodies in the Basin include Meiss Lake and spring-fed intermittent streams (DOI 1980). Butte Creek is the largest stream in the watershed (DOI 1980). Spring-fed perennial streams include Ikes, Prather, Muskgrave, and Harris, which drain into Meiss Lake (DOI 1980). Seikel Creek is a tributary of Muskgrave Creek and its water is partially diverted to Juanita Lake by the USFS (Novick 1996). Major surface water features are shown on Figure 1.1.

Historically, Mud Lake was a perennial lake residing southeast of Macdoel, with the aptly named Lakeview Cemetery on the east shore but has recently become a small intermittent pond (USGS topo map). Mud Lake was about 40 acres (0.16 sq km) in 1909, and was too alkaline for domestic or irrigation uses, but was used by cattle (USDA 1909). A water body south of Cedar Point has historically been called Alkali or Soda Lake and occupied 600 to 700 acres (2.4–2.8 sq km) in 1909, but was deemed far too alkaline for domestic or irrigation use (USDA 1909). The 1909 USDA Soil Survey observed a slight rise in the valley floor north of Macdoel towards Dorris, which separated Meiss Lake and Soda Lake (USDA 1909).

Outside the Basin, the Butte Valley Watershed includes three additional named streams and numerous small lakes and ponds. Antelope Creek was once a tributary of Butte Creek up until the eruption of the Butte Valley Basalt (King 1994). Spring-fed First and Horsethief Creeks are south of Ball Mountain (cf. USGS topo map). Intermittent surface water bodies in the high mountains of the southern watershed include: Duck Lake southwest of Haight Mountain, Surprise Lake on Ash Creek Butte; Antelope Creek Lakes and Hemlock Lake near Rainbow Mountain; and Frog Lake on the valley floor northeast of Rainbow Mountain. Intermittent surface water bodies on the valley floor of the middle Watershed include: Antelope Sink north of Cedar Mountain; Orr Lake at the base of Orr Mountain; the unnamed pond west of Cedar Mountain formed by the Butte Creek spillway, Russell Lake in Red Rock Valley; and a large unnamed lake between Tennant and Butte Creek at 41.615389 north latitude, -122.008856 west longitude. Intermittent surface water bodies in the high elevations northwest of Mount Hebron include: Mud Lake where U.S. Highway 97 leaves the Butte Valley floor; and Pumpkinseed Lake northwest of Mount Hebron. Perennial surface water bodies include Mud Lake on Mud Lake Ridge, Juanita Lake near Ball Mountain, Red Rock Lakes east of Sheep Mountain, and Deyarmie Lake in Red Rock Valley.

Meiss Lake

Meiss Lake is a shallow, alkaline water body that lies on the west side of the Valley and is managed by CDFW in BVWA. BVWA and Meiss Lake are important for the Pacific Flyway and are a major migration and staging area for waterfowl, sandhill cranes, and other water birds (NCRWQCB 2008). Meiss Lake is a 4,000 acre (16.2 sq km) managed reservoir, with a maximum depth of six feet (Novick 1996). Before the mid-1940s, Meiss Lake and adjacent wetlands covered about 10,000 acres (40.5 sq km) (NCRWQCB 2008). In 1909, the considerably deeper western half of Meiss Lake was 6 ft (1.8 m) deep, while the rest of the lake was only 2-3 ft (0.61-0.91 m) deep or less (USDA 1909). From the mid-1940s to 1981, Meiss Lake and adjacent wetlands were systematically diked, channeled, drained and converted to agricultural uses (NCRWQCB 2008). In the 1940s, a North-South dike was constructed to divide the lake in half and convert the western half into farmland (Novick 1996). The eastern half of the lake was used as a reservoir to manage inflowing and outflowing water (Novick 1996). In the winter, water from Muskgrave, Harris, and Ikes Creeks were diverted onto the fields to built soil moisture, then pumped into Meiss Lake in the spring for planting (Novick 1996). As noted above, the lake bed on the eastern half is four feet higher than the former lake bed in the west (Novick 1996). The farmland on the former lake bed has been periodically reflooded by Meiss Lake (Novick 1996). By 1981, Meiss Lake its adjacent wetlands and tributaries had been substantially altered, lost or degraded from their pre-1940s state (NCRWQCB 2008). After BVWA was purchased by the State in 1981, the wetlands and tributaries are being managed and restored (Novick 1996).

Meiss Lake is a closed basin and receives surface water from four spring-fed creeks and one canal (Novick 1996). From the west flow Ikes, Harris, and Muskgrave Creeks and from the south flows Prather Creek (Novick 1996). Estimated creek inflows are 15,000 to 20,000 acre-feet annually but are low or nonexistent in the summer and fall (Novick 1996). The Irrigated District Canal delivers excess irrigation water to Meiss Lake from wells and summer runoff, though flows are normally very low (Novick 1996). Seikel Creek, a tributary of Muskgrave Creek, is partially diverted by the USFS to Juanita Lake from April 30 to November 1 (Novick 1996). In the 1940s, dams were built at Juanita Lake to provide irrigation water to Meiss Ranch, the precursor of BVWA (Novick 1996).

Historically, the size of Meiss Lake has varied (Novick 1996). Commonly the lake nearly dries up by early fall (Novick 1996). Meiss Lake typically goes completely dry every 15-20 years and was dry in 1955, 1965, 1981, 1987, 1988, 1990, 1991 and 1992 (County of Siskiyou 1996). Precipitation patterns have continued to fluctuate, with a wet period between 1993 to 1999 and dry cycle from 2000 to 2008 (2006 was very wet) [2009 BVWA Plan Addendum]. Meiss Lake went dry in 2000, 2001, 2002, 2003, 2004, 2005, 2007, and 2008 [2009 BVWA Plan Addendum]. The hardpan and soil type at Meiss Lake create a large shallow impermeable basin subject to high evaporation rates (County of Siskiyou 1996). The pan evaporation rate for Butte Valley is estimated to be 48 in (1.2 m) per year, primarily driven by wind (Novick 1996; County of Siskiyou 1996).

The water quality of Meiss Lake is heavily dependent on the season, where the quality is good during and shortly after the winter-spring runoff period then declines during the summer and fall as inflows cease and evaporation increases (Novick 1996). During the summer and fall, electrical conductivity, pH, TDS, and alkalinity increase in value (Novick 1996). For example, pH is roughly 7.4 in the spring and 10.1 in the fall (Novick 1996). In general, the lake water has high turbidity due to the relatively shallow water (less than 6 ft) and is high in sodium bicarbonate. The high turbidity and alkalinity compared to the Klamath River restricts pumping of Meiss Lake water into the Klamath River after April 30 (Novick 1996). After July 1, BVWA does not use Meiss Lake water for crop irrigation or wetlands maintenance because alkalinity, pH, and electrical conductivity exceed safe levels for plant growth (Novick 1996).

Evidenced by the hundreds of feet of lake sediment on the Butte Valley floor, paleolakes have occupied the Valley for at least hundreds of thousands of years (King 1994). The flatness of the valley floor means small changes in Meiss Lake levels cause large changes in lateral lake size (King 1994). Two Holocene (0.012 Ma - Present) shorelines can be distinguished via aerial photography interpretation of soil and vegetation and archaeological evidence (King 1994). The prehistoric Meiss Lake at its maximum had its shoreline at the 4,236 ft (1,291 m) amsl elevation contour, covering an area of 11.6 sq mi (30 sq km) at a depth of 10 ft (3 m) (King 1994). The historic high level for Meiss Lake is 4,232 ft (1,290 m) amsl, which is marked by a change in vegetation (King 1994). The current Meiss Lake shoreline is at 4229 ft (1,289 m) amsl (King 1994). Above the prehistoric 4,236 ft (1,291 m) amsl shoreline, vegetation is marked by scrub vegetation similar to that growing on Quaternary lake deposits on the valley floor (King 1994). Between the historic 4,232 ft (1,290 m) amsl shoreline and prehistoric 4,236 ft (1,291 m) amsl shoreline, the vegetation is marked by grasses and scattered scrub (King 1994). Between the current lake shoreline and the historic 4,232 ft (1,290 m) amsl shoreline, the area is covered with grasses (King 1994).

Meiss Lake was likely below the 4,232 ft (1,290 m) amsl shoreline for most of the Holocene due to the well-defined soil profile between 4,232 ft (1290 m) and 4,239 ft (1292 m) amsl called the Pit Series, which suggests that the area has not been underwater for an extended time (King 1994). Soils in the historically drained Meiss Lake bed are classified as the Teeters Series and are less developed then the Pit Series (King 1994). Additionally, the Teeters Series soil is only 24 in (0.61 m) deep compared to the 40 in (1 m) deep Pit Series (King 1994).

Along the old Meiss Lake shorelines there is evidence of prehistoric human habitation (King 1994). Prehistoric habitations on the eastern shore are dated from 6,640 to 565 years before present along both the 4,236 ft (1,291 m) and 4,232 ft (1,290 m) amsl shorelines (King 1994). Additional prehistoric habitations along the west shore range from 9,000 to 1,400 years before present between 4229 ft (1,289 m) and 4,232 ft (1,290 m) amsl elevation (King 1994). The variation of elevations of the prehistoric habitations suggest that the prehistoric Meiss Lake was not dry for long periods of time and had at least some water through most of the Holocene (King 1994).

In December 1964, Meiss Lake flooded to an area of 16 sq mi (10,500 acres; 42.5 sq km), which coincides with the 4,234 ft (1,291 m) amsl elevation contour including its former lake bed and adjacent farms (County of Siskiyou 1996). The County declared the Butte Valley flood a Major Disaster (USACE) and requested emergency relief from the federal government (County of Siskiyou 2017). In early 1965, the U.S. Army Corps of Engineers constructed the Sam's Neck Flood Control Facility, a drainage canal to pump excess floodwater to the Klamath River (NCRWQCB 2008; County of Siskiyou 2017). The drainage canal consists of an outlet from Meiss Lake that travels up Sam's Neck, where a pump lifts water 21 ft (6.4 m) from the valley floor to Rock Creek and ultimately to the Klamath River in Oregon (Novick 1996; County of Siskiyou 2017). Rock Creek is outside the Butte Valley watershed and is a tributary of the Klamath River (County of Siskiyou 2017). By July 12, 1966, USACE was still pumping down Meiss Lake (County of Siskiyou 2017).

Management for the Sam's Neck Flood Control Facility has changed hands several times since its creation. The lift pumps require a contract for electricity and the facility requires maintenance (County of Siskiyou 2017). After completion of the project, USACE payed for one year's worth of power before turning over responsibility to the County (County of Siskiyou 2017). The County never expected to fund the project with taxpayer dollars and intended to hand over responsibility to the direct beneficiaries of the flood control project, originally BVID (County of Siskiyou 2017). BVID did not take over the project and the County authorized a local company to operate one of the lift pumps, with the condition that the company pay for all electric power bills and accept all liability (County of Siskiyou 2017). Months later the Pacific Power and Light Company requested that the County submit payment for a power bill associated with the pumps (County of Siskiyou 2017). After agreeing to pay the power bill, the County Board of Supervisors advised that the County would not be responsible for any further power bills from the pumping facilities thereafter (County of Siskiyou 2017). The Board of Supervisors also discussed that those benefiting from the flood control facility should pay for the power costs of the project or the power transformers should be removed (County of Siskiyou 2017). In the fall of 1967, the Board of Supervisors authorized the Meiss Ranch Company to operate the Flood Control Facility and soon after approved the arrangement between Meiss Ranch and Pacific Power and Light Company on a rolling year-to-year basis (County of Siskiyou 2017). From 1968 to mid-1985, the Flood Control Facility pumped excess floodwater from Meiss Lake at no cost to the County (County of Siskiyou 2017). Meiss Ranch may have made an agreement with BVID for operation of the pumps at the Ranch's expense (County of Siskiyou 2017).

Estimated yearly water volumes pumped from Meiss Lake are shown in Table 1.4. Sam's Neck Flood Control Facility usually only operated from January to April (Novick 1996). Public opposition restricted operation of the facility after April due to the impact of the poor lake water quality (turbid and alkaline) on the Klamath River fishery (Novick 1996).

In 1981, Meiss Ranch was purchased by the California Department of Fish and Game (currently CDFW), and the land was designated as the Butte Valley Wildlife Area (BVWA) (County of Siskiyou 2017). The Department initially operated and paid for the Flood Control Facility pumps until 1985 (County of Siskiyou 2017). The Department notified the County of releasing its operational and monetary responsibility for operating and maintaining the Sam's Neck Canal pumps (County of Siskiyou 2017). The Department outlined its long-term goal of utilizing all surplus water to create wetland habitat, which might eliminate the need for the Flood Control Facility (County of Siskiyou 2017). In 2017, the County submitted a request to the USACE that Sam's Neck Flood Control Facility be abandoned (County of Siskiyou 2017).

Table 1.4: Estimated Volume of Water Pumped From Meiss Lake to The Klamath River (BVWA 1996).

Year	Acre-Feet	Year	Acre-Feet
1968	638	1982	8,930
1969	585	1983	12,456
1970	10,064	1984	7,708
1971	12,545	1985	4,182
1972	14,582	1986	2,271
1973	89	1987	0
1974	9,674	1988	0
1975	4,164	1989	0
1976	142	1990	0
1977	89	1991	0
1978	4,571	1992	0
1979	213	1993	0
1980	4,363	1994	0
1981	0		

Butte Creek

Butte Creek is the largest stream in Butte Valley, with headwaters between the Whaleback and Haight Mountains at the southern end of the Watershed (Figure 1.8) (King 1994). Butte Creek historically flowed into Meiss Lake, but has been diverted for agricultural irrigation and spreading grounds for groundwater recharge (DOI 1980; Novick 1996). Butte Creek had been sufficiently appropriated and diverted that flows terminate near the town of Macdoel (Wood 1960). At normal flows, surplus water after irrigation is diverted into a lava crack or allowed to percolate into porous lava and alluvial deposits for groundwater recharge (Novick 1996; County of Siskiyou 1996). Flood flows are diverted into Dry Lake and Cedar Lake to recharge the Butte Valley Basalt water bearing formation, and does not reach Meiss Lake (Novick 1996; County of Siskiyou 1996).

In 1909, while supplying irrigation water for several hundred acres of alfalfa, timothy, clover, and grain crops, Butte Creek disappeared underground at the valley edge and flows to Meiss Lake via groundwater (USDA 1909). All surface evidence of the lower Butte Creek channel, from the Valley edge to Meiss Lake, has been destroyed by cultivation (King 1994).

Prather, Ikes, Harris, and Muskgrave Creeks

Prather, Ikes, Harris, and Muskgrave Creeks are spring-fed creeks that drain into Meiss Lake (Novick 1996). Seikel Creek and Juanita Lake are tributary to Muskgrave Creek (Novick 1996). Water from these creeks have excellent mineral quality, are soft with a calcium-magnesium bicarbonate character, and very low in chloride and sulfate (Novick 1996). Springs from the High Cascade Volcanics water bearing formation provide perennial flows for four creeks, but flows vary seasonally (County of Siskiyou 1996). Historically, Harris and Ikes Creeks flowed all year but very low during the summer months (Novick 1996). In recent years, Harris, Ikes, and Muskgrave Creeks all dry up in the summer and fall [Novick (1996); BVWA 2021 (April 2021 GSP comment)]. Upstream of BVWA, Prather Creek is diverted for agriculture and summer flows to Meiss Lake are very low to nonexistent (Novick 1996). All four creeks are capable of intense flooding in a short period of time and all floodwater flows into and is managed by BVWA (Novick 1996). CDFW is the