16. Geology, Minerals, Soils, and Paleontology

16.1 Introduction

This chapter describes the geologic, minerals, soils, and paleontologic setting for the Extended, Secondary, and Primary study areas. Descriptions and maps of these three study areas are provided in Chapter 1 Introduction.

Permits and authorizations for Geology, Minerals, Soils, and Paleontology resources are presented in Chapter 4 Environmental Compliance and Permit Summary. The regulatory setting for Geology, Minerals, Soils, and Paleontology resources is presented in Appendix 4A Environmental Compliance.

This chapter focuses primarily on the Primary Study Area. Potential impacts in the Secondary and Extended study areas were evaluated and discussed qualitatively. Potential local and regional impacts from constructing, operating, and maintaining the Sites Reservoir Project (Project) alternatives were described and compared to applicable significance thresholds. Mitigation measures are provided for identified potentially significant impacts, where appropriate. Because none (i.e., no potentially significant impacts) were identified for minerals, no mitigation is included in this chapter for this resource.

16.2 Environmental Setting/Affected Environment

16.2.1 Extended Study Area

16.2.1.1 Geology

Of the 48 contiguous states, California contains the highest and the lowest elevations only 80 miles apart, plus a variety of rocks, structures, and mineral resources equaled by few areas in the world (Norris and Webb, 1990).

California's landscapes are extremely varied, ranging from the broad nearly flat floor of the Great Valley to the jagged glaciated Sierra Nevada. Eleven geomorphic provinces[1] are recognized (Figure 16-1): the Sierra Nevada, the Klamath Mountains, the Cascade Range, the Modoc Plateau, the Basin and Range, the Mojave Desert, the Colorado Desert, the Peninsular Ranges, the Transverse Ranges, the Coast Ranges, and the Great Valley.

California's geologic diversity, in part, is attributed to its location astride two major tectonic plates: the North American Plate and the Pacific Plate. The active San Andreas Fault, heading north out of the Gulf of California, westward along the Transverse Ranges, then northwestward within and west of the Coast Ranges up to Cape Mendocino, separates the North American Plate from the Pacific Plate. Active faulting is an important feature of California's structural pattern. The San Andreas Fault has been crucial in California's geologic history since at least the Miocene epoch (approximately 23 million years ago [MYA]). The ground surface at the fault has moved as much as 350 miles. Other important faults are the Calaveras and Hayward in the San Francisco Bay area, the Nacimiento in the southern Coast Ranges, the San Jacinto of the Peninsular Ranges, the Sierra Nevada in eastern California, and the Garlock, which separates the Mojave Desert from the Sierra Nevada and the Basin and Range.

[1] The geomorphic provinces are topographic-geologic groupings based primarily on landforms and late Cenozoic structural and erosional history.

Legend

Delevan Overhead Power Line and Pipeline

Proposed Sites Reservoir

Geomorphic Provinces of California

FIGURE 16-1
Geomorphic Provinces of California
Sites Reservoir Project EIR/EIS

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The oldest rocks found in California are metamorphic rocks as much as 1.8 billion years old, which occur in the San Gabriel and San Bernardino mountains and in the Mojave and Basin and Range provinces. During the Paleozoic era (approximately 600 MYA), most of California was below sea level and thick sequences of marine sediments were deposited. These sediments ranged from near-shore limestone in the east to deeper-water deposits composed of volcanic detritus[2] from offshore islands mixed with oceanic crustal materials. Marine conditions continued into the Mesozoic era (beginning approximately 260 MYA) but with active subduction[3] as the Pacific Plate plunged under the North American Plate. The sea withdrew to the west and mountains developed in eastern California accompanied by some granitic intrusive activity. With some pauses or interruptions, subduction continued through the latter part of the Mesozoic era when granitic intrusions were again voluminous and very widespread.

Granitic rocks from the Mesozoic era are by far the most abundant igneous rocks in California and are exposed in most provinces. Sedimentation continued offshore in deep marine basins from material stripped off the rising mountains to the east and from volcanic material derived from a chain of offshore volcanic islands; these sediments later become known as the Franciscan Complex. Marine sedimentation decreased in the Cenozoic era (beginning approximately 70 MYA), confined primarily in and west of the San Joaquin Valley and in scattered locations in Southern California. Subduction slowed considerably later in the Cenozoic era, but compressive forces continued, raising the Coast Ranges and eventually closing off the Central Valley from the Pacific Ocean. Beginning in the Eocene epoch and continuing to the Pleistocene, the Central Valley inland basin gradually filled in with continental deposits. During the Pleistocene epoch[4] (approximately 2.6 MYA), extensive glaciation sculpted the Sierra Nevada and other mountain ranges, and large inland lakes developed west of the Sierra Nevada.

16.2.1.2 Minerals

California's geology has resulted in a wealth of mineral resources, including industrial, metallic, and nonmetallic minerals. These minerals are important to the state's economy. During the last 15 years, California has ranked between first and eighth out of the U.S. states in non-fuel mineral production. In 2014, over 2 dozen non-fuel mineral commodities – valued at $3.5 billion – were produced from 660 California mines (California Geological Survey [CGS], 2016). California's major mineral resources include sand, gravel, crushed stone, cement, gold, silver, iron, evaporite[5] minerals, and clay.

Sand and gravel are California's most valuable industrial minerals. Most sand and gravel are mined from alluvial deposits, which include sediment from streams and alluvial fans. Increasingly restrictive environmental regulations have significantly curtailed the mining of alluvial deposits for use as aggregate in California. Crushed rock sources of aggregate are becoming more common. Other important industrial minerals are Portland cement, crushed stone, and boron.

Gold is the major metallic mineral mined in California. The most productive gold mining areas include the Sierra Nevada and the Mojave Desert. Silver is produced as a byproduct of gold mining, and a small amount of iron is mined in the Mojave Desert region. Copper and zinc were mined extensively in the past

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[2] Volcanic detritus is loose fragments, such as sand or gravel, which has been worn away from rock.

[3] Subduction is a geologic process in which one edge of one crustal plate is forced below the edge of another.

[4] An epoch is the shortest division of geologic time.

[5] Evaporite is a nonclastic sedimentary rock composed primarily of minerals produced from a saline solution as a result of extensive or total evaporation of the solvent. Examples include gypsum, anhydrite, rock salt, primary dolomite, and various nitrates and borates.

century, particularly in the Klamath Mountains and the Sierran foothills; production has decreased substantially in recent decades.

Other economically important nonmetallic minerals include borates, which are mined in Southern California, and gypsum and clay minerals.

Oil has been found in 18 counties in California, primarily in the San Joaquin Valley and Southern California. Small amounts of oil are also produced in the Northern California near Eureka. Natural gas is generally formed with oil; however, natural gas is produced in the Sacramento Valley without any recoverable oil resources.

Ultramafic[6] rocks, possibly containing localized veins of asbestos, occur widely throughout California (CGS, 2000a). The nearest ultramafic rock formations are located approximately 8 miles west of the proposed Sites Reservoir.

16.2.1.3 Soils

California has over 700 distinct soil series map units.[7] California soil types vary extensively. In the mountains of Northern California, where precipitation is higher and vegetation abundant, soil depths are generally deeper with a greater abundance of clay. At lower elevations, such as the Sacramento Valley, rich alluvial soils predominate, supporting an extensive agricultural region. Soils within the Southern California coastal plains and adjacent mountains are more clastic (i.e., clay-poor) due to lower precipitation and less vegetation. Soil development east of the Sierra Nevada and the desert portions of Southern California is less extensive.

16.2.1.4 Paleontology

Table 16-1 shows the fossil locations and number of fossils found in a database search of the Extended Study Area. Fossils found in the Extended Study Area range from microfossils (fossils of single-celled organisms) to large megafossils (fossils of larger organisms, ranging from small invertebrates to large mammals). Several counties contain more fossil localities than there are actual fossils on record. Typically, these localities represent sites where fossils have been discovered, but the specimens have yet to be added to the database. Because no impacts to paleontological resources are anticipated in the Extended Study Area, a full paleontological inventory review of the Extended Study Area was not conducted.

[6] Ultramafic rocks are igneous rocks that form in high temperature environments well below the surface of the earth. By the time they are exposed at the surface by uplift and erosion, ultramafic rocks may be partially to completely altered to serpentinite, a type of metamorphic rock in which small amounts of chrysotile asbestos are common.

[7] The soil series is the lowest category of the national soil classification system. The name of a soil series or the phase of a soil series is the most common reference term used in soil map unit names. The name of a soil series is also the most common reference term used as a soil map unit component. The purpose of the soil series category is closely allied to the interpretive uses of the system, though map unit components provide the interpretive applications within soil survey for most detailed purposes. Soil series are the most homogeneous classes in the system of taxonomy (Natural Resources Conservation Service, 2011).

Table 16-1
Fossils and Fossil Locations within the Extended Study Area

County	UCMP Database		PaleoBiology Database
	Fossils	Localities	Localities
Alameda	2,553	508	16
Butte	134	144	26
Colusa	72	211	7
Contra Costa	18,286	2,562	0
El Dorado	53,948	22	0
Fresno	5,069	2,245	93
Glenn	24	238	5
Kern	38,044	2,046	178
Kings	7,379	840	35
Los Angeles	23,360	2,136	170
Madera	235	14	1
Merced	314	273	14
Napa	54	144	5
Orange	5,069	1,106	182
Placer	779	64	1
Plumas	138	75	6
Riverside	1,870	209	179
Sacramento	126	13	3
San Benito	677	490	1
San Bernardino	8,416	723	183
San Diego	11,722	1,771	354
San Joaquin	969	97	10
San Luis Obispo	1,890	1,642	37
Santa Barbara	3,680	1,922	157
Santa Clara	319	190	19
Shasta	11,042	826	207
Solano	1,450	297	13
Sutter	76	37	2
Tehama	395	812	84
Tulare	12	26	0
Ventura	7,725	1,096	216
Yolo	350	133	17

Note:

UCMP = University of California Museum of Paleontology at Berkeley

Source: UCMP, 2016; PaleoBiology Database, 2016

16.2.2 Secondary Study Area

16.2.2.1 Geology

The Secondary Study Area occurs primarily in the eastern portion of the Coast Range Geomorphic Province and the northwestern portion of the Great Valley Geomorphic Province (Figure 16-1). Additionally, portions of the Klamath Mountains, Cascades, Modoc Plateau, Basin and Range, and the Sierra Nevada geomorphic provinces are within the Secondary Study Area. These are described below.

Coast Range Geomorphic Province

The Coast Range Geomorphic Province is characterized by a series of north-northwest trending ranges and valleys; few are continuous for more than 100 miles. The province extends approximately 600 miles from Point Arguello northward to the Klamath Range (Norris and Webb, 1990) and varies in width from a few miles to 70 miles.

The Coast Ranges are complex and consist of many types of rocks ranging in age from Jurassic (206 MYA) to Tertiary (present time). The Franciscan Formation is composed of metamorphosed sedimentary and igneous rocks. It represents the basement rocks of the Coast Ranges to the west of the project area. The general structural trend is northwest.

The eastern portion of the Coast Range is composed of a thick sequence of Upper Mesozoic (65 to 145 MYA) sedimentary rocks known as the Great Valley Sequence (GVS). The section consists principally of sedimentary rocks that are folded and faulted, and are not affected by other than mild metamorphism. The GVS is divided into several formations that are generally based upon particle size. Although the naming system for these formations has been subject to many revisions (e.g., Blake et al., 1992; Dickinson and Rich, 1972; Rich, 1971; Ingersoll, 1979), for this study, the pertinent formations of the GVS (from oldest to youngest) include the Stony Creek, Lodoga, Boxer, Venado, Cortina, and Yolo. Quaternary (1.8 MYA to Present) units in the Coast Range include stream deposits consisting of clay, silt, sand, gravel, cobbles, and boulders found in recent stream channels. Stream deposits are derived from the older components of the Franciscan Complex and the GVS. Hillside deposits occur along slopes or at their bases. It consists of soil, but contains a sizable fraction of angular rock fragments and some organic material. Landslide deposits are similar to hillside deposits, but are more defined and generally deeper. Landslide deposits tend to occur on steeper slopes.

Great Valley Geomorphic Province

The Great Valley Geomorphic Province is a nearly flat alluvial plain extending from the Tehachapi Mountains in the south to the Klamath Mountains in the north; to the Sierra Nevada in the east and the Coast Ranges in the west. The valley consists of the San Joaquin River drainage to the south of the Sacramento-San Joaquin Delta, and the Sacramento River drainage to the north. This northwest-trending trough has been filled with a thick (several miles deep) (Wahrhaftig and Birman, 1965) accumulation of sediments eroded from the adjacent ancestral Sierra Nevada and Klamath Mountain ranges from the Jurassic to the Present. It has a long stable eastern shelf supported by subsurface granite and a short western flank with basin sediments. The western edge has eroded to form a series of northwest-trending eastward-dipping ridges of sandstone and conglomerate separated by valleys underlain by siltstone and mudstone.

Rock units on the surface in the Great Valley Geomorphic Province close to the Secondary Study Area range in age from Miocene to Recent (23.8 MYA to Present).

The Lovejoy basalt is a dense and very hard extrusive volcanic rock (i.e., lava flow). The basalt originated approximately 23 MYA from an unknown volcanic center near the eastern margin of the Sierra Nevada. Lovejoy exposures are found in the Orland Buttes on the west side of the Central Valley and as far south as Vacaville. Extensive outcrops of the Lovejoy are located in the Oroville area.

The Tehama Formation occurs as thin, discontinuous, stream-transported fan deposits throughout the western edge of the Sacramento Valley that were derived from the erosion of the Coast Ranges and Klamath Mountains. Eastward, the deposits thicken and merge, forming a broad thick plain that contains pale green to tan semi-consolidated sand, tuffaceous[8] sand, and silt with lenses of gravel. The Tehama Formation is the primary groundwater aquifer of the Sacramento Valley west of the Sacramento River. The Nomlaki Tuff Member occurs near the bottom of the Tehama Formation and has been age-dated at approximately 3.3 million years. It consists of white, tan, or pink dacite pumice tuff and lapilli tuff that is approximately 30 feet thick along the west side of the valley. Most of the tuff is believed to have been deposited as an ash fall from a major volcanic eruption east of the project region.

The Red Bluff Formation occurs primarily in the northern portion of the Sacramento Valley, where it overlies the Tehama Formation. Its largest area is in the vicinity of the City of Red Bluff where it is approximately 50 feet thick. It consists largely of gravels with minor amounts of interbedded sands. The upper surface usually consists of a hardpan soil. In the Red Bluff area, rock fragments are metamorphic and igneous types, indicating that the sediments were transported from the north Coast Ranges and Klamath Mountains. The formation was probably deposited during a period when glaciers were active in the adjacent mountain areas. Streams draining the glacial areas were heavily choked with coarse debris and suspended fine-grained material. The suspended clay and silt particles filled the voids after deposition of the gravel so that most of the Red Bluff gravels are not very permeable. The Red Bluff remnants represent an extensive Pleistocene (1.8 MYA to 11,600 years ago) nearly level erosional surface that once covered much of the northern Sacramento Valley.

The Riverbank Formation consists of weathered reddish gravel, sand, and silt and is divided into an upper and lower member. It is differentiated from the younger Modesto Formation by its terraces being higher topographically and by its more developed soil profile. The upper member is unconsolidated, but compact, dark brown to red alluvial gravel in a matrix of sand, silt, and clay. The lower member consists of red semi-consolidated gravel, sand, and silt. The lower member generally is higher topographically in stream-cut terraces and more dissected than the upper layer.

The Modesto Formation consists of the lowest distinct alluvial terraces present above the Holocene (11,600 years ago to Present) stream deposits. It includes tan and light gray gravelly sand, silt, and clay. The upper layer is unconsolidated and unweathered, and it forms the lowest terraces approximately 10 feet thick over older alluvial deposits. The lower layer can be slightly weathered and forms terraces that are higher than the upper layer. Soils on the lower layer contain clay and are red.

Recent stream channel deposits, floodplain, and flood basin deposits make up the remainder of rock types that crop out in the Sacramento Valley. Stream channel and floodplain deposits consist of well-sorted sand, gravel, and silt adjacent to the major streams. Flood basin deposits are the finest grained materials, consisting mostly of clay and silt. The deposits are thin and poorly permeable. Flood basin deposits in the project area occur in the Colusa Basin along the west side of the Sacramento River from approximately Princeton southward.

[8] Tuffaceous sand is a rock composed of compacted volcanic ash varying in size from fine sand to coarse gravel.

The Tuscan and Laguna formations, important water-bearing formations beneath the Sacramento Valley, crop out along the eastern portion of the Sacramento Valley. Further discussion of these formations is included in Chapter 10 Groundwater Resources.

Klamath Mountains Geomorphic Province

The Klamath Mountain Geomorphic Province is divided into four north-south trending terranes.[9] From east to west, these terranes are the Eastern Klamath, Central Metamorphic, Western Paleozoic and Triassic, and Western Jurassic. The terranes increase in age from west to east, except for the Central Metamorphic Terrane, which is slightly older than the Eastern Klamath Terrane. The rock units generally dip to the east, with the older eastern units overlying the younger western units. To varying degrees, these rock units are exposed throughout the 40-mile reach of the mainstem Trinity River. Older gold-bearing stream channel deposits, as well as recent channel deposits, occur along rivers and creeks.

Cascades Geomorphic Province

The Cascades Geomorphic Province, from southern British Columbia to south of Lassen Peak, is a volcanic terrane ranging in age from Pliocene to Holocene. The province has been divided into the Western Cascade series and the High Cascade series. The Western Cascade series consists of Miocene-aged basalts, andesites, and dacite flows interlayered with rocks of explosive origin, including rhyolite tuff, volcanic breccia, and agglomerate. This series is exposed at the surface in a belt 15 miles wide and 50 miles long from the Oregon border to the town of Mount Shasta. Early High Cascade rocks formed very fluid basalt and andesite that extruded from fissures to form low shield volcanoes. Large composite cones like Mount Shasta and Mount Lassen had their origins during the Pleistocene. Mount Lassen was the only active volcano in California in the 20th century. Mount Shasta was last active in the 18th century when steam and ash erupted from the summit cone (Norris and Webb, 1990).

Modoc Plateau Geomorphic Province

The Modoc Plateau Geomorphic Province consists of a high plain of irregular volcanic rocks of basaltic origin. The numerous shield volcanoes and extensive faulting on the plateau give the area more relief than may be expected for a plateau. The Modoc Plateau averages 4,500 feet in elevation and is considered a small part of the Columbia Plateau, which covers extensive areas of Oregon, Washington, and Idaho.

Basin and Range Geomorphic Province

The Basin and Range Geomorphic Province, located east of the Modoc Plateau and the Sierra Nevada, extends eastward into western Utah. It is characterized as north-south trending mountain ranges separated by low wide alluvial valleys derived from eroded materials from the adjacent mountain ranges. In general, the drainage is internal (i.e., no outlet to the sea) with saline lakes occupying low spots. One area, the Sierra Valley, drains westward into the Middle Fork Feather River. Rocks range from metamorphic rocks of pre-phanerozoic age (approximately 1.8 billion years ago to Recent) lakebed and stream deposits. Paleozoic and early Mesozoic sedimentary and metamorphic rocks constitute the bulk of the bedrock. The topography of the Basin and Range is a result of crustal extension within this part of the North American Plate. The crust has been stretched up to 100 percent of its original width, and underneath the Basin and Range, it is of the thinnest in the world.

[9] Terranes are areas having a preponderance of a particular rock or rock groups.

Sierra Nevada Geomorphic Province

The Sierra Nevada Geomorphic Province is comprised principally of Cretaceous granitic pluton,[10] remnants of Paleozoic and Mesozoic metavolcanic and metasedimentary rocks, and Cenozoic volcanic and sedimentary rocks. The Paleozoic and Mesozoic metavolcanic and metasedimentary rocks were intruded by the granitic plutons approximately 77 to 225 MYA, resulting in local uplift and deformation of the overlying older rock. Regional uplift and rapid erosion of most of the overlying metamorphic rocks closely followed intrusion of the plutons, exposing the underlying granitic rocks. Continued uplift and erosion, accompanied by volcanic activity and alpine glaciation, resulted in the present pattern of deep-walled valleys that characterize the Sierra Nevada.

16.2.2.2 Minerals

The mineral resources within the Secondary Study Area are the same as was described for the Extended Study Area. The exceptions are iron and gypsum, which are mined in Southern California, but are not found in the Secondary Study Area.

Ultramafic rocks, possibly containing localized veins of asbestos, occur in the Coast Ranges, Klamath Mountains, and the Sierra Nevada (CGS, 2000a). Chromite was mined intermittently from ultramafic rocks in Glenn County in the vicinity of the town of Chrome approximately 23 miles northwest of the proposed Sites Reservoir. Mining activity ceased in the 1940s.

16.2.2.3 Soils

Soils in the western portion (i.e., the Coast Range foothills) of the Secondary Study Area are a byproduct of erosion of the underlying sedimentary rocks. Typical foothill soils are shallow to deep, generally well-drained, and fine- to medium-textured. Soil depth on steep slopes is moderate to very thin; slightly weathered sandstone and intensely weathered mudstones can be encountered within just a few inches of the surface. Soil depth increases on the gentler slopes, generally reaching its maximum thicknesses along valley bottoms. These deeper soils are more developed, moderately drained, and finer-grained; organic material is more common in the low-lying deeper soils.

Soils in the central portion (i.e., the Sacramento Valley) of the Secondary Study Area are a byproduct of the underlying weathered alluvial deposits. Most valley soils are alluvial silt loams, clays, and sands deposited by the Sacramento River and tributaries draining the west side of the valley. These soils are typically very deep to moderately deep, poorly drained, and fine-textured. The majority of the alluvial soils on the valley floor has high agricultural productivity and is designated as Prime Agricultural[11] soils. Some soils are limited in their ability to support many forms of agriculture because of alkali problems and/or drainage problems caused by the presence of a cemented hardpan or dense clay layer. These poorly drained soils are particularly well suited for growing rice.

Soils in the northern and eastern portions of the Secondary Study Area (i.e., the Klamath, Cascades, and Sierra Nevada) are a byproduct of the underlying metamorphic, volcanic, and intrusive rocks. In general, they are more clay-rich than the alluvial soils of the Sacramento Valley.

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[10] Plutons are masses of igneous rock that have solidified below the surface of the earth.

[11] Prime Agricultural means that the soil meets the physical and chemical criteria for Prime Farmland or Farmland of Statewide Importance, as determined by the Natural Resources Conservation Service.

16.2.2.4 Paleontology

Table 16-2 shows the fossil locations and number of fossils found in the Secondary Study Area. As in the Extended Study Area, the recovered fossils range from microfossils to the bones of large mammals. Several counties contain more fossil localities than actual fossils because not all fossils from known localities have been added to the database at this time (the localities have been listed, but the specimens from those sites have yet to be entered into the database). Construction activities in the Secondary Study Area are limited to the installation of two new pumps at the Red Bluff Pumping Plant, and maintenance activities are limited to the dredging of the intakes; neither operation would involve excavation into sediments with the potential to yield fossils. Because these activities are not expected to affect paleontological resources, a full paleontological inventory review of the Secondary Study Area was not conducted.

Table 16-2
Fossils and Fossil Locations within the Secondary Study Area

County	UCMP Database		PaleoBiology Database
	Fossils	Localities	Localities
Alameda	2,553	508	16
Butte	134	144	26
Colusa	72	211	7
Contra Costa	18,286	2,562	81
Del Norte	4	83	3
El Dorado	3,948	22	0
Glenn	24	238	5
Humboldt	1,049	699	10
Placer	779	64	1
Sacramento	126	13	3
Santa Clara	319	190	19
Shasta	11,042	826	207
Solano	1,450	297	13
Sutter	76	37	2
Tehama	395	812	84
Trinity	1,084	96	0
Yolo	350	1,096	216
Yuba	0	3	0

Note:

UCMP = University of California Museum of Paleontology at Berkeley

Source: UCMP, 2016; PaleoBiology Database, 2016

16.2.3 Primary Study Area

16.2.3.1 Geology

Table 16-3 lists the Coast Range rock units and the Sacramento Valley rock units within the Primary Study Area. Figure 16-2 is a generalized geologic map of the Primary Study Area (CGS, 2000b). Detailed mapping of the rock units within the Sacramento Valley (Helley and Harwood, 1985) is also shown on Figure 16-2.

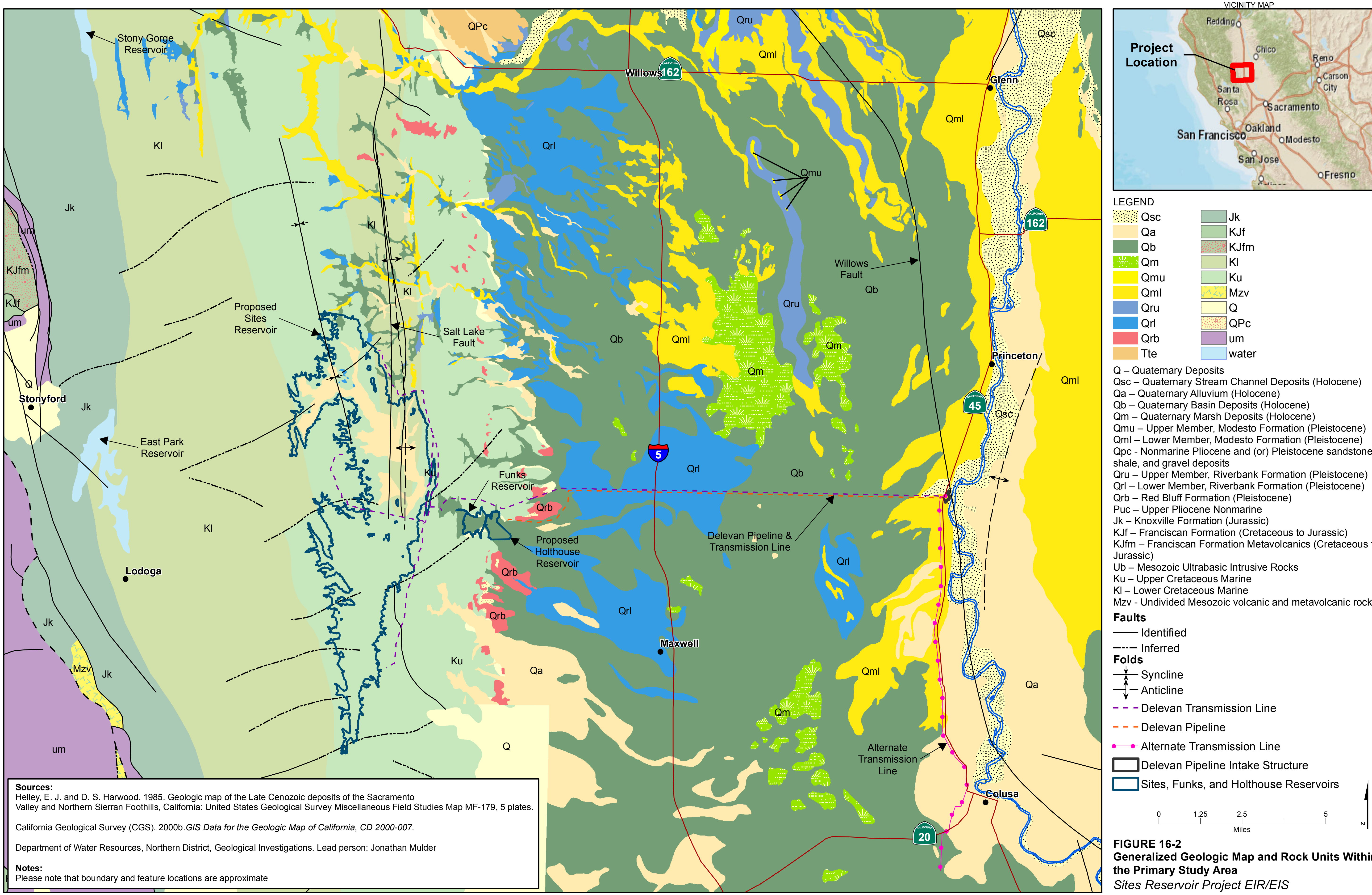

FIGURE 16-2
Generalized Geologic Map and Rock Units Within the Primary Study Area
Sites Reservoir Project EIR/EIS

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Table 16-3
Coast Range Rock Units in the Primary Study Area

Coast Range Rock Units		
Geologic Period	**Rock Unit**	
Quaternary 1.8 MYA to Present	Stream channel deposit, slope wash, landslide deposits	
Upper Cretaceous 65 to 100 MYA	Cortina Formation (Includes Venado and Sites sandstone members) Boxer Formation	Franciscan Formation
Lower Cretaceous to Upper Jurassic 100 to 160 MYA	Lodoga Formation Stony Creek Formation	Franciscan Formation
Great Valley Rock Units		
Geologic Period	**Geologic Epoch**	**Rock Unit**
Quarternary	Holocene 11,600 years ago to Present	Stream channel deposits Flood plan deposits Basin deposits
Tertiary	Pleistocene 2.6 MYA to 11,600 years ago	Upper Modesto Formation Lower Modesto Formation Upper Riverbank Formation Lower Riverbank Formation Red Bluff Formation
	Pliocene 5.3 to 1.8 MYA	Tehama Formation
	Miocene 23.8 to 5.3 MYA	Lovejoy Basalt

Sites Reservoir Inundation Area, Sites Reservoir Dams, and Recreation Areas

Sites Reservoir and its dams would be underlain by sedimentary rocks of the GVS. The GVS is composed of Jurassic-Cretaceous marine sandstones, siltstones, and mudstones trending north by northwest and dipping steeply to the east. Older sedimentary rocks of the GVS occur to the west, and younger sedimentary rocks occur to the east.

Within the footprint of the Sites Reservoir, the GVS is primarily composed of the Boxer Formation. The Boxer Formation consists of thinly bedded mudstones with thin to medium sandstone/siltstone. The mudstone of the Boxer Formation is more erodible than the sandstone, thus forming the broad gentle relief of the Antelope Valley. The saddle dam foundations along the northeastern portion of the reservoir would be sited in the Boxer Formation.

The prominent ridge along the eastern shore of Sites Reservoir is formed from the contact between the underlying Boxer Formation and the more resistant Cortina Formation. The Cortina Formation consists of a greater proportion of sandstone, with moderate to thick mudstone interlayers. The basal member of the Cortina Formation, the Venado Sandstone, is the geologic unit in which the Golden Gate Dam and the Sites Dam foundations would be built.

Younger deposits of Late Quaternary (8,000 year ago to Present) deposits occur within the Sites Reservoir footprint, primarily along the stream valleys of Stone Corral Creek, Antelope Creek, Funks Creek, and Grapevine Creek in Antelope Valley. The deposits are composed primarily of fine-grained sands, silts, and clays derived from the surrounding Boxer Formation. Larger fragments of igneous and metamorphic rock occur in the deposits and are derived from upland areas west of the valley. They generally occur as stream channel and floodplain deposits; minor colluvium deposits occur on higher gentler slopes away from the streams. Floodplain deposits typically contain beds of sandy gravel and silty sand. Stream channel deposits consist of sandy silt and gravel inset into either the floodplain or terrace deposits. In general, the deposits are rather thin (less than 30 to 50 feet) with a maximum thickness reached adjacent to the downcut stream channels on the eastern side of Antelope Valley.

The recreation areas would be located on either the Boxer Formation or the Cortina Formation.

Sites Pumping/Generating Plant, Tunnel from Sites Pumping/Generating Plant to Sites Reservoir Inlet/Outlet Structure, Sites Reservoir Inlet/Outlet Structure, Sites Electrical Switchyard, and Field Office Maintenance Yard

The Sites Generating/Pumping Plant would be sited on the eastern slope of a prominent ridge composed of sandstones and mudstones of the Cortina Formation. Quaternary alluvium covers the alignment trace of the intake canal. The tunnel alignment would be in mostly Cortina Formation mudstones and sandstone, except for its western opening which would be in mudstones of the Boxer Formation. The Inlet/Outlet Structure would be sited in the Boxer Formation. The Sites Electrical Switchyard would be sited in sandstone of the Cortina Formation. The Field Office Maintenance Yard would be sited primarily in sandstone with occasional thin beds of mudstone of the Lodoga Formation.

Holthouse Reservoir Complex

Bedrock within and surrounding the existing Funks Reservoir is composed primarily of thinly bedded mudstones of the Yolo Member of the Cortina Formation. Due west of Funks Reservoir, the Sites member of the Cortina Formation is older geologically, and occurs as a more resistant ridge of thin to medium bedded sandstone and siltstones. Typically, the mudstone members are more susceptible to weathering and erosion, forming broad low valleys or swales between the more resistant sandstone. A more resistant outcrop of sandstone occurs near the downstream portion of Funks Reservoir in the vicinity of the existing Funks Dam. The Holthouse Reservoir Complex would be sited in thinly bedded mudstones of the Yolo Member of the Cortina Formation. Younger deposits of the Late Quaternary (8,000 year ago to Present) occur on top of the bedrock around and inundated by Funks Reservoir; the Holthouse Reservoir Complex would also be sited on these deposits.

Glenn-Colusa Irrigation District Canal

Geologic units along the alignment trace of the Glenn-Colusa Irrigation District (GCID) Main Canal consist of (from youngest to oldest) the Basin Deposits, Upper and Lower Modesto Formation, and Upper and Lower Riverbank Formation. Descriptions of these geologic units are included in Section 16.2.2.1.

The GCID Main Canal headworks are located on the Lower Riverbank Formation. From approximately 1 mile south of the headworks to Stony Creek, the Canal then crosses the Lower Modesto Formation. Between Stony Creek and Willows, the Canal crosses the Upper and Lower Modesto Formation and the Riverbank Formation, as well as basin deposits. From Willows south to the Funks Reservoir, the Canal crosses primarily basin deposits and isolated deposits of Upper Modesto Formation and Upper Riverbank Formation.

Tehama-Colusa Canal

Geologic units along the alignment of the Tehama-Colusa Canal consist of (from youngest to oldest) the Basin Deposits, Upper and Lower Riverbank Formation, Upper and Lower Modesto Formation, Red Bluff Formation, Tehama Formation, and Cortina Formation. Descriptions of these geologic units are included in Section 16.2.2.1.

From Willow Creek to Funks Reservoir, the Canal crosses primarily deeply weathered mudstones, siltstones, and minor thin beds of sandstone of the Cortina Formation between drainage divides and younger alluvium or basin deposits at stream crossings.

Delevan Pipeline and Sites/Delevan Overhead Power Line

Geologic units along the east-west alignment of the Sites/Delevan Pipeline and overhead power line consist of (from youngest to oldest) recent Sacramento River stream deposits, Basin Deposits, Lower Riverbank Formation, Lower Modesto Formation, and Cortina Formation. Geologic units along the north-south alignment of the overhead power line consist of recent Sacramento River stream and alluvial deposits, and the Lower Modesto Formation. Descriptions of these geologic units are included in Section 16.2.2.1.

Terminal Regulating Reservoir, Glenn-Colusa Irrigation District Canal Connection to the Terminal Regulating Reservoir, Terminal Regulating Reservoir Pipeline, Terminal Regulating Reservoir Pipeline Road, Terminal Regulating Reservoir Pumping/Generating Plant and Electrical Switchyard

Geologic units underneath and adjacent to the proposed location of the terminal regulating reservoir (TRR), GCID Main Canal Connection to the TRR, TRR Pipeline, TRR Pipeline Road, TRR Pumping/Generating Plant and Electrical Switchyard consist of Basin Deposits and the Lower Riverbank Formation. Descriptions of these geologic units are included in Section 16.2.2.1.

Delevan Pipeline Intake/Discharge Facilities

Geologic units underneath the proposed location of the Delevan facilities consist of recent Sacramento River stream deposits, Lower Modesto Formation, and the Tehama Formation. Descriptions of these geologic units are included in Section 16.2.2.1. The stream deposits and Lower Modesto Formation are relatively thin (less than 20 feet) and are underlain by the more resistant Tehama Formation. The Tehama Formation is less readily erodible and defines the western edge of the Sacramento River channel.

Road Relocations and South Bridge

Geologic units underneath the proposed location of the road relocations consist of the Boxer and Cortina Formations of the GVS (Section 16.2.2.1). Additionally, these older deposits are occasionally overlain by younger sedimentary deposits of Late Quaternary (8,000 year ago to Present).

Project Buffer

Geologic units underneath the portion of the Project Buffer that would surround Sites Reservoir and the inlet/outlet facilities, as well as the Holthouse Reservoir Complex, consist primarily of the Boxer and Cortina formations of the GVS (Section 16.2.2.1), with smaller portions of Basin Deposits, upper and lower members of both the Riverbank and Modesto formations, and Red Bluff Formation.

Geologic units underneath the portion of the Project Buffer that would surround the TRR facilities consist of Lower Riverbank Formation, Basin Deposits, and Red Bluff Formation.

Geologic units underneath the portion of the Project Buffer that would surround the Delevan Pipeline Intake/Discharge Facilities consist of Lower Modesto Formation and recent Sacramento River stream deposits.

16.2.3.2 Minerals

With the exception of an inactive dimensional stone quarry to the east of the proposed Sites Dam location, no known economic mineral resources occur in Primary Study Area. The stone quarry is not within the reservoir inundation area and no other locally important mineral resources exist within the Primary Study Area (Glenn County, 1997; Colusa County, 2011).

Natural gas production occurs widely in the Primary Study Area with large gasfields in the Sacramento Valley, such as the Willows-Beehive Bend Field. Between 1948 and 1972, 10 exploratory wells were drilled within the footprint of the proposed Sites Reservoir; all 10 wells were “dry holes” (i.e., produced no natural gas). Approximately 10 exploratory wells (all “dry holes”) were also drilled near the alignment of the Delevan Pipeline.

Ultramafic rocks possibly containing localized veins of asbestos are not found within the Sites Reservoir footprint or buffer area or in watersheds draining into the reservoir. Ultramafic rocks have been identified at the western edge of the Primary Study Area approximately 6.5 miles west of the Sites Reservoir buffer area (CGS, 2000a).

16.2.3.3 Soils

The soils in the Primary Study Area have been mapped by the Soil Conservation Service (now the Natural Resources Conservation Service [NRCS]), and are described in the soil surveys of Colusa and Glenn counties (NRCS, 2006; Begg, 1965). In addition, the NRCS provides soil data in GIS format and software (Soil Data Viewer) for detailed analysis of soil properties.

The Primary Study Area includes two physiographic provinces: the Sacramento Valley and the Coast Range foothills (NRCS, 2006).

Floodplains extending along both sides of the Sacramento River slope gently away from the river to the Butte Sink to the east and Colusa Basin to the west. Frequent overflows under natural conditions have deposited loamy soils high in content of silt and fine sand. A levee system combined with Shasta Reservoir upstream helps to control Sacramento River waters so that floodplains are no longer flooded on a regular basis.

The soils on the floodplains along the Sacramento River are very fertile and are among the best soils in the Sacramento Valley. Several sloughs originally disseminated from the Sacramento River into the Butte Sink and Colusa Basin. Water flow was stopped by construction of levees on the Sacramento River.

These sloughs, particularly the Sycamore Slough, carried river sediments several miles from the river, creating the very productive Vina soils. West from the floodplains along the Sacramento River, the Colusa Basin extends north and south through the Primary Study Area. Overflows containing clayey sediments from the Sacramento River and foothill streams regularly filled the Colusa Basin. Because of the construction of levees on the Sacramento River, only sediments from the foothill streams now reach the basin. The basin is mostly leveled for rice production. Salts in the clayey sediments from the foothill streams were deposited in the basin soils, particularly Willows soils, and reclamation of the soils has been ongoing since early in the 20th century. Most basin soils have been reclaimed to several feet. The very deep clay deposits that are characterized by extremely slow permeability and a shallow water table hamper further reclamation.

Alluvial fans exist along the west side of the Sacramento Valley. They originate at the base of the foothills, at elevations of 200 to 400 feet, and gently descend to the east for several miles to the Colusa Basin. Under natural conditions, streams from the foothills flooded these alluvial fans, depositing fertile loamy soils. Many of the streams have been diverted from their natural channels, and levees have been constructed in some areas to control flooding.

Most of the foothill region is drained by streams flowing east to the Sacramento Valley. These streams occasionally carry heavy volumes from high rainfall events, and cause flooding in the Sacramento Valley along the west-side alluvial fans and in the Colusa Basin. Increased runoff has scoured and lowered the stream channels of many foothill streams. Some streams have been diverted or channelized in the Sacramento Valley. The foothill streams eventually find their way to the Colusa Basin and to the Colusa Basin Drain. Occasionally, the flow exceeds the capacity of the south-flowing Colusa Basin Drain, and widespread flooding occurs in the basin.

The Coast Range foothills range from approximately 200 to 2,500 feet in elevation. The lower foothills have rolling slopes in many areas and have clayey soils and very few oak trees. In most foothill areas, the soils are strongly sloping and are shallow or moderately deep over sandstone and mudstone of the GVS. Most small valleys in the foothills have gently sloping clayey soils and some areas of loamy soils.

The NRCS has mapped 61 soil types within the Primary Study Area. Appendix 16A Soil Types within the Primary Study Area provides the soil map unit name, the county in which it occurs, a map unit description, and several soil properties, such as erosion potential, shrink/swell potential, corrosion of steel potential, and corrosion of concrete potential. Soil property values were derived using the NRCS Soil Data Viewer software.

Sites Reservoir Inundation Area (1.3 MAF and 1.8 MAF)

Thirty-four soil types occur within the proposed Sites Reservoir footprint for Alternative A (1.3 million acre-feet [MAF]). Of these, 13 soil types make up approximately 92 percent of the total area (Table 16-4). The remaining 21 soil types make up less than 8 percent of the total area.

Table 16-4
Major Soil Types at Sites Reservoir (Alternative A)

Soil Type	Acreage	Percent of Total	Cumulative Percent of Total
Capay clay	2,961.7	24.25	24.25
Altamont-Sehorn complex	2,315.8	18.96	43.20
Sehorn-Altamont complex	1,872.8	15.33	58.54
Corval loam	1,529.4	12.52	71.06
Altamont silty clay	841.4	6.89	77.94
Corning clay loam	348.9	2.86	80.80
Millsholm-Contra Costa association	311.4	2.55	83.35
Altamont-Contra Costa clays	193.8	1.59	84.94
Hillgate loam	191.2	1.57	86.50
Clear Lake clay	176.5	1.44	87.95
Zamora silty clay	174.2	1.43	89.37
Myers clay	172.4	1.41	90.78
Millsholm-Rock outcrop association	160.1	1.31	92.09

Thirty-six soil types occur within the proposed Sites Reservoir footprint for Alternatives B, C, and D (all are 1.8 MAF). Of these, 15 soil types make up approximately 93 percent of the total area (Table 16-5). The remaining 21 soil types make up less than 7 percent of the total area.

Table 16-5
Major Soil Types at Sites Reservoir (Alternatives B, C, and D)

Soil Type	Acreage	Percent of Total	Cumulative Percent of Total
Capay clay	3,070.7	21.49	21.49
Altamont-Sehorn complex	2,633.9	18.43	39.92
Sehorn-Altamont complex	2,441.7	17.09	57.01
Corval loam	1,608.8	11.26	68.27
Altamont silty clay	902.7	6.32	74.58
Millsholm-Contra Costa association	527.7	3.69	78.28
Corning clay loam	357.3	2.50	80.78
Altamont-Contra Costa clays	324.6	2.27	83.05
Millsholm-Rock outcrop association	315.1	2.21	85.25
Myers clay	214.8	1.50	86.76
Hillgate loam	192.9	1.35	88.11
Altamont soils	192.5	1.35	89.45
Zamora silty clay	178.6	1.25	90.70
Clear Lake clay	176.5	1.24	91.94
Nacimiento-Contra Costa association	164.9	1.15	93.09

Sites Reservoir Dams

Fourteen soil types occur within the footprints of the Sites Dam, Golden Gate Dam and associated small saddle dam, and the six northern saddle dams for Alternative A. The Sites Dam location is predominantly underlain by the Millsholm-Contra Costa association soil type (14.3 acres) and a smaller amount of Corval loam (1.0 acre). The Golden Gate Dam and associated small saddle dam locations are underlain entirely by the Millsholm-Rock outcrop association soil type (41.0 acres). The six northern saddle dam locations are underlain primarily by Nacimiento-Contra Costa association (15.2 acres), Capay clay (11.0 acres) and Altamont soils (5.6 acres) with lesser amounts of Zamora silty clay (2.8 acres), Sehorn-Millsholm association (1.0 acre), and Millsholm very rocky sandy loam, Willows clay, Tehama clay loam, Altamont-Contra Costa clays, and Myers clay (each less than 0.5 acre).

The same fourteen soil types occur within the footprints of the Sites Dam, Golden Gate Dam, and nine northern saddle dams for Alternatives B C, and D. The Sites Dam location is predominantly underlain by the Millsholm-Contra Costa association soil type (18.1 acres) and a smaller amount of Corval loam (1.2 acres). The Golden Gate Dam location is underlain by the Millsholm-Rock outcrop association soil type (15.1 acres), the Capay clay (10.8 acres), the Corval loam (10.4 acres), and lesser amounts of Millsholm-Contra Costa association (0.6 acre) and Sehorn-Altamont complex (0.05 acre) soil types. The nine northern saddle dam locations are underlain primarily by Nacimiento-Contra Costa association (37.1 acres), Capay clay (20.0 acres), Altamont soils (17.0 acres), Sehorn-Millsholm association (8.1 acres), Altamont-Contra Costa clay (3.2 acres) and Sehorn-Altamont complex (3.0 acres) with lesser amounts of Zamora silty clay (2.6 acres), and Tehama clay loam, Willows clay, Millsholm-Rock outcrop association, and Sehorn-Millsholm-Gullied land complex (each less than 1.6 acres).

Soil cover at the proposed Sites and Golden Gate dam sites is very thin and is derived from the interbedded sandstone and siltstones of the Venado Sandstone. Soil cover at the seven (Alternative A) and nine (Alternatives B, C, and D) saddle dam sites is moderately deep with gradual transition into the mudstones and siltstones of the Boxer Formation.

Recreation Areas

The Recreation Areas would be underlain predominantly by Sehorn-Altamont complex (302.9 acres), Millsholm-Contra Costa association (264.8 acres), Nacimiento-Contra Costa association (217.0 acres), Millsholm-Contra Costa complex (129.1 acres), Altamont-Sehorn complex (119.5 acres), and Capay clay (96.0 acres) soils. The remaining 74.1 acres would be underlain by five other soil types in lesser amounts.

Road Relocations and South Bridge

The Road Relocations and South Bridge (including a 200-foot-wide construction disturbance area) would be underlain by 43 different soil types. Total affected area is approximately 1,329 acres. The predominant soil types are Millsholm-Contra Costa association (273.1 acres), Sehorn-Altamont complex (234.9 acres), and Capay clay (210.7 acres). The remaining 610.6 acres are composed of 40 other soil types with acreages ranging from 79.5 acres to 0.1 acre.

Sites Pumping/Generating Plant and Electrical Switchyard, Tunnel from Sites Pumping/Generating Plant to Sites Reservoir Inlet/Outlet Structure, Sites Reservoir Inlet/Outlet Structure, and Field Office Maintenance Yard

The Sites Pumping/Generating Plant would be located within the footprint of the proposed Inlet/Outlet Structure. The Tunnel would be entirely underground with openings in the outlet and inlet structures. The Inlet/Outlet Structure would be underlain predominantly by Millsholm-Rock outcrop association (34.7 acres), Corval loam (24.1 acres), and Sehorn-Altamont complex (15.0 acres) soils, with lesser amounts of Capay clay (8.7 acres), and Millsholm-Contra Costa association (7.6 acres) soils. Nearly

10 acres of Inlet/Outlet structure would be located in the footprint of the existing Funks Reservoir; no NRCS soils data are available for that area. The Sites Electrical Switchyard would be underlain by the Millsholm-Rock outcrop association. The Field Office Maintenance Yard would be underlain almost entirely by the Millsholm-Rock outcrop complex (18.0 acres) with a small portion by Capay clay (0.3 acre).

Holthouse Reservoir Complex

No NRCS soils data are available for the footprint of the existing Funks Reservoir. The proposed Holthouse Reservoir Complex would be underlain predominantly by Capay clay (129.2 acres) and Capay clay loam (74.0 acres) soils with lesser amounts of Hillgate clay loam (62.2 acres), Altamont-Sehorn complex (39.8 acres), Corval clay loam (36.1 acres), and Altamont silty clay (18.9 acres).

Terminal Regulating Reservoir, Glenn-Colusa Irrigation District Canal Connection to the Terminal Regulating Reservoir, Terminal Regulating Reservoir Pumping/Generating Plant, and Terminal Regulating Reservoir Electrical Switchyard

The TRR, GCID Main Canal Connection to the TRR, TRR Pumping/Generating Plant, and TRR Electrical Switchyard would be underlain by Capay clay loam (114.2 acres) and Hillgate clay loam (90.6 acres) soils, with 4.7 acres of Corval clay loam.

Glenn-Colusa Irrigation District Canal Facilities Modifications

The three modifications are primarily within the footprint of the existing GCID Main Canal; soil data within the footprint is unavailable (i.e., noted as water on soil map). At the railroad siphon location, Myers clay is present on both sides of the Canal. At the new headgate location, Hillgate loam is present on both sides of the Canal. The 200-foot canal lining feature is entirely within the footprint of the existing GCID Main Canal.

Delevan Pipeline, Terminal Regulating Reservoir Pipeline, Terminal Regulating Reservoir Pipeline Road, and Delevan Pipeline Electrical Switchyard

The Delevan Pipeline would be underlain predominantly by Willows silty clay (96.5 acres) and Hillgate clay loam (51.8 acres) with lesser amounts of Capay clay loam (28.0 acres), Corval clay loam (23.2 acres), Moonbend silt loam (8.5 acres), Corbiere silt loam (6.4 acres), and Vina loam (2.1 acres).The construction disturbance area for the Delevan Pipeline (totaling approximately 2,365 acres) would be underlain predominantly by Willows silty clay (1,175.6 acres), Hillgate clay loam (379.8 acres), Capay clay loam (277.3 acres), Corval clay loam (247.3 acres), Moonbend silt loam (101.3 acres), and Corbiere silt loam (84.9 acres). Six other soil types make up the remaining 86 acres in lesser amounts.

The TRR Pipeline, TRR Pipeline Road, and Delevan Pipeline Electrical Switchyard would be underlain predominantly by Hillgate clay loam (6.5 acres) with a lesser amount of Capay clay loam (2.1 acres). The construction disturbance area for these three facilities would be entirely within the construction disturbance area of the Delevan Pipeline.

Sites/Delevan Overhead Power Line

The east-west alignment of the Sites/Delevan Overhead Power Line route for Alternatives A, B, and C would be located within the construction disturbance area of the Delevan Pipeline, except for an approximately 4-mile portion extending west of the proposed TRR. This discussion addresses only that portion of the overhead power line outside of the Delevan Pipeline construction disturbance area. The proposed Sites/Delevan Overhead Power Line route (west of the TRR) would be underlain predominantly by Altamont silty clay (23.6 acres), Corval loam (9.5 acres), Millsholm-Rock outcrop association, (8.3 acres), Capay clay (5.8 acres), and Altamont-Sehorn complex (5.4 acres). Seven other soil types make up the remaining 20.6 acres in lesser amounts.

The north-south alignment of line for Alternative D would run from the Delevan Pipeline Intake/Discharge Facilities to a substation located west of Colusa near Highway 20. More than 80 percent of the route is underlain by Moonbend Silt Loam.

Delevan Pipeline Intake/Discharge Facilities (Alternatives A, C, and D)

The proposed Delevan Pipeline Intake/Discharge Facilities would be underlain by Vina loam (17.4 acres). A portion of the facility (1.7 acres) would extend into the river; no NRCS soils data are available for that area.

Delevan Pipeline Discharge Facility (Alternative B)

The proposed Delevan Pipeline Discharge Facility would be underlain by Vina loam (7.64 acres). A portion of the facility (0.1 acre) would extend into the river; no NRCS soils data are available for that area.

Project Buffer

The Project Buffer would surround all Primary Study Area Project facilities, with the exception of the Delevan Pipeline, Sites/Delevan Overhead Power Line, portions of the roads, and the GCID Main Canal Facilities Modifications. The soil types underlying the Project Buffer are, therefore, similar to soils described above for the facilities that it would surround.

16.2.3.4 Paleontology

Methodology

Geological maps and geological literature were reviewed to provide the physiographic and geological context for the Primary Study Area. Internet queries and two standard online databases were also used to determine the relative potential for paleontological resources to be found in each of the rock units described below. The databases are the UCMP (reviewed October 2016) and the PaleoBiology Database (reviewed October 2016), managed by a consortium of academic institutions and supported, in part, by the National Science Foundation. The results of the search of paleontological site records are presented in Appendix 16B Colusa County Fossil Sites.

The following tasks were completed to establish the paleontologic sensitivity and distribution of rock units (including unconsolidated sediments) exposed within the Primary Study Area:

- The study area was defined and its physiographic and geologic context was described.
- A stratigraphic inventory (i.e., a review of the composition and relative positions of the rocks) of the area was completed, and the mapped geologic units within the Primary Study Area were identified.
- A paleontological records review of the area was completed to identify previously recorded fossil resources and the context of their discovery.

The mapped geologic units were assigned levels of paleontological sensitivity based on the fossil remains previously documented within that unit and on other relevant geological and paleontological data.

The paleontological sensitivity of the Primary Study Area was assessed by identifying the geological units that might yield fossils, and therefore, have paleontological potential using the approach described above. A description of the geological units is provided above; Appendix 16C Results of the Paleontological Resources Literature Review presents the results of the review of the available geological literature focused on paleontological sensitivity assessment.

The distribution of stratigraphic units was determined through geologic mapping and used as a proxy for paleontological sensitivity. The features of the Project were then laid out on the geological map, and the Project facilities that have the potential to cross units of varying paleontological sensitivity (high, moderate, unknown, low, or no sensitivity) were delineated.

Paleontological Inventory of the Primary Study Area

Guidelines for paleontological resources assessments (Society of Vertebrate Paleontology [SVP], 2010) call for the inventory of all geological units within 1 mile of the ground-disturbing activities associated with any project (Appendix 16C Results of the Paleontological Resources Literature Review) to ensure that both surficial geologic units and geologic units that would be encountered in the subsurface are adequately analyzed. These geological units are then evaluated for paleontological sensitivity. During the preparation of this chapter, several data gaps were identified that complicate characterization of the paleontological sensitivity of the Primary Study Area. These include the following:

- Geologic maps at the necessary level of detail for this analysis tend to group all pre-Tertiary formations into the same category.
- There are few published geological studies of the GVS and overlying Neogene and Quaternary sediments within the limits of the project.
- There are proportionately few paleontological studies of these same rocks.

Older rocks referred to as the GVS occur only on the western portion of the Primary Study Area in the foothills of the North Coast Ranges. In the Sacramento Valley, much younger Pliocene (approximately 5.3 to 2.6 MYA) and Quaternary (2.6 MYA to present) sediments are found.

The results of the search of paleontological site records are summarized in Table 16-6. A comprehensive list of sites recorded in Glenn and Colusa counties is provided in Appendix 16B Colusa County Fossil Sites. Although the Primary Study Area includes only the Project area plus a 1-mile buffer, all localities were recorded for each formation because the paleontological sensitivity of a geologic unit is based on the abundance of fossils within the entire unit (though local variations in the rock are taken into account).

Many of the recorded paleontological localities in the GVS are microfossil samples (chiefly small plankton fossils, including foraminifera and diatoms). The use of microfossils in age dating, correlation, and in paleoenvironmental studies is well documented. However, rocks bearing only microfossils are not typically assigned high or even moderate levels of paleontological sensitivity because these fossils are very abundant and found in many different sedimentary units, and therefore are not scientifically significant as individuals. Also, although microfossils usually possess scientific significance as an assemblage, isolated specimens or samples of microfossils normally have little scientific use.

Table 16-6
Results of Paleontological Records Search by Geological Unit for the Primary Study Area

Formation, Member, or Unit Name[a]		Number of Localities on Record[a]	
		UCMP Database	PaleoBiology Database
Great Valley Sequence rocks (marine sediments older than 65 million years)			
1	Boxer	1[b]	0
2	Antelope Shale	17	2
3	Fiske Creek	2	0
4	Julian Rocks	0	0
5	Brophy Canyon	0	0
6	Cortina	0	0
7	Venado Sandstone	19	0
8	Yolo	7	2
9	Sites	11	0
10	Funks	4	2
11	Rumsey	0	0
12	Guinda	18	0
13	Forbes	51	7
14	Dobbins Shale	1	1
15	Hoodoo Hills	0	0
Late Neogene and Quaternary Sediments (younger than approximately 5.7 million years)			
1	Tehama (sites in Colusa, Glenn, and Tehama counties only)	31	0
2	Red Bluff	13[c]	0
3	Victor[d]	1	0
4	Riverbank	11	2
5	Modesto	8	0

[a]Includes names that are no longer in use, but which may still be attached to fossil collection records (Appendix 16C Results of the Paleontological Resources Literature Review).

[b]Limited to microfossil collections.

[c]Collections from the early 20th Century may now be attributed to a different unit, most likely the Tehama Formation.

[d]Name superseded, but collections from the early 20th Century may still bear this designator.

Note:

UCMP = University of California Museum of Paleontology at Berkeley

Source: UCMP, 2016; PaleoBiology Database, 2016 (Appendix 16B Colusa County Fossil Sites)

Cretaceous Marine Units

The databases consulted (UCMP, 2016; PaleoBiology Database, 2016) included references to paleontological sites in 10 of the 15 Cretaceous geological units comprising the GVS. Of these, three (the Boxer, Fiske, and Sites formations) are known to yield only microfossils (chiefly foraminifera and radiolaria). The remaining seven of the GVS units in the Primary Study Area yield scientifically significant megafossils.

The comparative lack of marine sedimentary units that have yielded megafossils is consistent with the inferred paleoenvironments represented by these units. They are deep-ocean sediments consisting of muds of the abyssal ocean floor and trench, and sandstones of deep submarine fans. The depth of water during deposition of the GVS has been calculated as greater than 13,000 feet (Ingersoll, 1979). At that depth, few animals can be expected to be incorporated into the paleontological record due to a combination of geochemical and ecological factors, including low probability of preservation due to both the low density of animals at abyssal depths (the deep sea floor), and the fact that seawater at such depths dissolves calcite shells. In considering the paucity of fossil record from the GVS, Haggart and Ward (1984) observed that many paleontologists have had difficulty correlating Cretaceous strata of the GVS due to the lack of large fossils. Therefore, most studies have relied on microfossils to determine the relative age and stratigraphic position of these units, and most records for the GVS in the databases consulted (UCMP, 2016; PaleoBiology Database, 2016) consist of these microfossil assemblages.

Changes in the species composition of microfossils that lived at shallow depths have been the principal means of assigning strata to different ages within the Cretaceous period. However, with more intensive collecting, Haggart and Ward (1984) demonstrated that megafossils, primarily mollusks, can be found in at least the Santonian and Campanian strata (85.8 to 70.6 MYA) on the west side of the Sacramento Valley. Some of these fossils have been instrumental in clarifying the timing of deposition of the upper portion of the GVS (Haggart and Ward, 1984). The paleontological records of the seven GVS units that yield megafossils are discussed in Table 16-7.

Table 16-7
Great Valley Sequence Units in the Primary Study Area that Yield Megafossils

Description
Antelope Shale: The gastropod *Paosia* (*Trajanella) colusaensis* was recovered from rocks that are likely from either the Antelope Shale or the overlying Venado Sandstone (Squires, 2004). The specimens were from near the town of Sites and are donated specimens, so the exact locale for this collection is uncertain. The gastropods *Paosia californica* and *Turitella petersoni* are from the upper part of the Antelope Shale (Brown and Rich, 1961). Similar to the Venado Sandstone above it, many of the invertebrates are thought to be shallow water fauna redeposited in submarine deposits, which may compromise some of their scientific value because the original context or depositional setting of the specimens would be in doubt.
Venado Sandstone: Similar to the Antelope Shale, many of the invertebrates found in the Venado are thought to have been redeposited in submarine deposits. The UCMP database notes that the collections there include important specimens of the Cenomanian to early Turonian (99.6 to 89.3 MYA) bivalve *Yaadia leana*.
Yolo Formation: The Turonian (93.5 to 89.3 MYA) Yolo Formation has yielded mollusks of the genus *Turridea* (Oqvist, no date.) as well as an array of ammonites (Squires, 2004). Also present in this unit is the gastropod *Paosia californica* (Squires, 2004).
Funks Formation: The texanitid ammonites (a type of cephalopodl) are relatively rare in Cretaceous sediments of the Pacific Coast, and the Funks Formation is important because it has yielded more than 2 dozen specimens of *Protexanites thompsoni* (Jones, 1966), a member of this group. The type site is approximately 1 mile north of Putah Creek, well south of the current Primary Study Area.
Guinda Formation: The gastropod *Paosia californica* and the bivalve *Cucullaea melhaseana* have been recovered from this unit (Squires, 2004). The uppermost portions of this formation yield specimens of the index fossil *Bostrychoceras elongatum*, an ammonite (Haggart and Ward, 1984).
Dobbins Shale: The lower half of the Dobbins Shale contains the ammonite *Bostrychoceras elongatum*, establishing that the species' range continued into this unit from the underlying Guinda Formation. Uppermost portions of the Dobbins Shale contain abundant specimens of the pelecypod *Inoceramus schmidti*, a lower Campanian (83.5 to 70.6 MYA) index fossil (Haggart and Ward, 1984).
Forbes Formation: The transition between the Dobbins Shale and the overlying Forbes Formation contains the important ammonite *Baculites chicoensis*, which allows correlation of this unit of the GVS with the upper member of the Chico Formation on the east side of the Sacramento Valley (Haggart and Ward, 1984).

Pliocene and Quaternary Terrestrial Units

Tehama Formation

The diverse fossil assemblage from the Pliocene (5.3 to 2.6 MYA) Tehama Formation (including the outdated Victor and Red Bluff Formations [Appendix 16C Results of the Paleontological Resources Literature Review]) documents conditions in California not long before the beginning of the environmental changes accompanying the Pleistocene (2.6 to 0.01 MYA) ice ages, and the animals living in those environments. The discovery of the remains of a giant tortoise (*Geochelone*) from the Tehama Formation near Red Bluff (Sierra College, 2007) adds to the list of animals from the Tehama Formation that already included several records of the giant tortoise, as well as *Pliomastodon* (mastodon); *Mammut* (mammoth); *Equus simplicidens, Pliohippus, and Nannippus* (horses); *Camelops hesternus* (North American camel); Megalonichidae and *Mealonyx* (ground sloth);*Platygonus* (a pig-like animal); *Canis* (dog); *Odocoileus* (a genus of deer); *Thomomys* (pocket gopher); *Neotoma* (wood or pack rat); *Peromyscus* (deer mice); *Reithrodontomys* (harvest mice); *Osteichtheyes* (fish); and the hyena-like dog *Borophagus diversidens*.

Riverbank Formation

A variety of Pleistocene age (2.6 to 0.01 MYA) fossils were identified in extensive gravel pit excavations in east Sacramento (Hansen and Begg, 1970). They report a variety of Rancholabrean fossils (from about 125,000 to 10,000 years B.P.) collected from two gravel quarries in the Riverbank Formation. These fossils include: *Archoplites* (sunfish), two bird species, *Bison antiquus* (bison), *Camelops hesternus* (camel), *Canis dirus* (dire wolf), *Canis latrans* (coyote), *Clemmys marmorata* (pond turtle), *Colubridae* (colubrid snake), *Cyprinidae* (carp), *Equus* (horse), *Mammuthus* (mammoth), *Microtus* (meadow mouse or vole), *Neotoma* (wood rat), *Odocoileus* (deer), *Paramylodon harlani* (ground sloth), *Perognathus* (pocket mouse), *Scapanus latimanus* (mole), *Spermophilus* cf. *S. beecheyi* (ground squirrel), *Sylvilagus* (rabbit), *Thomomys bottae* (pocket gopher), as well as remains of trees such as *Pseudotsuga* (Douglas fir), *Platanus* (sycamore), and *Salix* (willow).

A variety of fossils of extinct large mammals were collected by Hilton et al. (2000), including *Glossotherium harlani* and *Paramylodon harlani* (ground sloths), *Bison antiquus* (bison), *Equus* sp. (horse), *Camelops hesternus* (camel), *Sciurus* sp. (squirrel), and *Mammuthus* sp. (mammoth), as well as plant fossils during the excavations for a large sports arena north of Sacramento. These fossils were found in excavations approximately 13 to 30 feet below the ground surface. These fossils were attributed to the Riverbank Formation.

Dundas and Cunningham (1993) also collected Pleistocene-age ground sloth (*Glossotherium harlani*) and Columbian mammoth (*Mammuthus columbi*) remains from the Riverbank Formation in the Extended Study Area.

Modesto Formation

Similar to the Riverbank Formation, the Modesto Formation is represented by a variety of deposits, mainly river deposits, but also terrestrial sediment such as dune fields and sand sheets. The fossil record of the Late Pleistocene Modesto Formation is, therefore, similar to the Riverbank Formation, although the taxa represented in the Modesto are generally from a more recent time period. The extinct North American camel is well represented in collections from the Modesto. Other vertebrates that have been recovered from the Modesto Formation include Jefferson's ground sloth (*Megalonyx*), mammoth (*Mammuthus*), and an extinct species of bison.

Sensitivity Criteria

The paleontological sensitivity of a rock unit is qualitatively determined by the likelihood that it will yield identifiable, unique, or scientifically important fossils. The fundamental assumption (SVP, 2010) is that formations will yield fossils of similar quality and quantity to what they have produced in the past.

An individual fossil specimen may be considered unique or significant if it is (1) identifiable, (2) complete, (3) well preserved, (4) useful in determining the age of the formation, (5) useful in interpreting the ancient environment, (6) a member of a rare species, or (7) a skeletal element different from, or a specimen more complete than, those now available for its species. The value or importance of different fossil groups varies, depending on the age and depositional environment of the rock unit that contains the fossils, their rarity, the extent to which they have already been identified and documented, and the ability to recover similar materials under more controlled conditions (such as part of a research project).

The following tasks were completed to establish the paleontological sensitivity of each rock unit potentially exposed in the Primary Study Area:

- Designated certain unit names as not applicable (n/a) because they duplicate other names being used, or because they are otherwise no longer used by geologists
- Considered the scientific significance of the fossil finds from the unit
- Assessed the potential paleontological productivity of each rock unit exposed within 1 mile of the Sites Reservoir Project features, based on available documentation
- Considered the potential for a rock unit exposed at the project feature site to contain a unique paleontological resource

Paleontological Sensitivity of Sediments in the Primary Study Area

The paleontological sensitivity of any part of the Primary Study Area depends almost entirely on its geology. Table 16-8 presents a summary of the paleontological sensitivity for the rock units that may be affected by Sites Reservoir Project features in the Primary Study Area.

The paleontological record of the GVS consists largely of microfossils. None of the GVS units are known to have an abundance of paleontological resources because they were deposited in a deep ocean setting; however, rare macrofossils such as bivalves, ammonites, and gastropods have been found in these units. Although uncommon in the GVS, these fossils are important for dating the geologic units they are found in and for comparing geologic units throughout the Great Basin. The Venado, Yolo, Sites, Funks, Rumsey, Guinda, and Forbes formations, and the Dobbins shale, are considered to have a “moderate” paleontological sensitivity rating (Table 16-8). If large fossils, including invertebrate fossils, are encountered during Project construction, they would likely be scientifically significant.

Neither the Modesto nor the Riverbank formations within the Primary Study Area are assigned “high” paleontological sensitivity. These formations have yielded important fossils; however, the recorded paleontological sites are located primarily near the Sacramento River and along its major tributaries. The paleontological productivity of the geologic units deposited at higher elevations in the Primary Study Area does not appear to be substantial. Therefore, the paleontological sensitivity of the Modesto and Riverbank formations is considered “moderate.”

Table 16-8
Paleontological Sensitivity of the Rock Units within 1 Mile of Any Proposed Primary Study Area Project Facility

Formation, Member, or Unit Name Attributed[a]		Sensitivity[b]	Remarks
Great Valley Sequence Rocks (Upper Cretaceous; Older than 65 Million Years)			
1	Boxer	low	-
2	Antelope Shale	moderate	-
3	Fiske Creek	low	Herein treated as equivalent with the Boxer Formation
4	Julian Rocks	low	Herein treated as equivalent with the Boxer Formation
5	Brophy Canyon	low	Herein treated as equivalent to the lower Boxer Formation
6	Cortina	low	-
7	Venado Sandstone	moderate	-
8	Yolo	moderate	-
9	Sites	moderate	-
10	Funks	moderate	-
11	Rumsey[c]	moderate	-
12	Guinda[c]	moderate	-
13	Forbes[c]	moderate	-
14	Dobbins Shale[a]	moderate	-
15	Hoodoo Hills[a]	n/a	Name no longer in use
Pliocene and Quaternary Sediments (Younger than Approximately 5.7 Million Years)			
1	Tehama	high	-
2	Red Bluff	low	-
3	Victor	n/a	Name no longer in use
4	Riverbank	moderate	Surficial sediments affected by soil development are not paleontologically sensitive; most fossil sites are from near the Sacramento River or its major tributaries
5	Modesto	moderate	Surficial sediments affected by soil development are not paleontologically sensitive. Includes unnamed Pleistocene units; most fossil sites are from near the Sacramento River or its major tributaries

[a]Some of these names are outdated and no longer in use, but nevertheless fossil localities are recorded as occurring within them. Databases are not updated when the geological nomenclature is revised.

[b]Sensitivity ratings were assigned based on the guidelines outlined by the SVP (2010), and by *Instructional Memorandum 2008-009* (Bureau of Land Management, 2008). They are:

- High: A geologic unit known to be paleontologically productive and to contain fossil assemblages that include scientifically important species.
- Moderate: A geologic unit that is known to yield scientifically significant fossil specimens, but may not be paleontologically productive in any given area.
- Low: A geologic unit that is known to yield few identifiable fossils.

[c]These units do not outcrop within the Primary Study Area; however, they were included in this analysis because they may be encountered in the subsurface and, given the nature of the nomenclature of the GVS, to ensure all fossils within the Primary Study Area have been adequately analyzed.

16.3 Environmental Impacts/Environmental Consequences

16.3.1 Evaluation Criteria and Significance Thresholds

Significance criteria represent the thresholds that were used to identify whether an impact would be potentially significant. Appendix G of the *CEQA Guidelines* suggests the following evaluation criteria for geology, minerals, soils, and paleontological resources:

Would the Project:

- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse?
- Result in substantial soil erosion or the loss of topsoil?
- Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?
- Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater?
- Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?
- Result in the loss of availability of a locally important mineral resource recovery site delineated on a local General Plan, Specific Plan, or other land use plan?
- Expose people (working on the Project or the public) during Project construction or operation to naturally occurring asbestos?
- Directly or indirectly destroy of a unique paleontological resource or site or unique geologic feature?

The evaluation criteria used for this impact analysis represent a combination of the Appendix G criteria and professional judgment that considers current regulations, standards, and/or consultation with agencies, knowledge of the area, and the intensity of the environmental effects, as required pursuant to the National Environmental Policy Act. For the purposes of this analysis, a project alternative would result in a potentially significant impact if it would result in any of the following:

- Potentially significant effects on a geologic unit or soil unit from Project construction, operation, and maintenance.
- Project construction, operation, and maintenance major effects on soil erosion and major loss of topsoil.
- Risks to life and property from Project construction, operation, and maintenance on expansive soil.
- Project construction, operation, and maintenance effects on soils that are incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the wastewater disposal.
- Loss of availability of a known mineral resource that would be of value to the region and the residents of the state.

- Loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan.
- Expose people to naturally occurring asbestos during Project construction, operation, or maintenance
- Project construction, operation, and maintenance effects on paleontological resources.

Paleontological resources impacts would include damage or destruction of a scientifically significant fossil, the removal of a scientifically significant fossil from its stratigraphic context, or any other action that reduces the amount of information available to future researchers. The probability that excavations would cause such impacts is proportional to the paleontological sensitivity of the geologic units. Excavations within high-sensitivity geologic units have a high potential to adversely impact paleontological resources. Excavations within moderate-sensitivity sediments have a lower potential to adversely impact paleontological resources, and that potential is frequently limited to specific portions of the unit. Low-sensitivity sedimentary units have a very low, but non-zero, chance of impacting paleontological resources. Excavations that do not impact paleontological resources—or that only impact non-significant fossils, such as microfossils—are not considered to impact paleontological resources. Impacts to sediment of moderate to high paleontological sensitivity, or to scientifically important fossils, would constitute potentially significant impacts in the absence of mitigation.

16.3.2 Impact Assessment Assumptions and Methodology

Combinations of Project facilities were used to create Alternatives A, B, C, C_1, and D. In all resource chapters, the Sites Project Authority (Authority) and Reclamation described the potential impacts associated with the construction, operation, and maintenance of each of the Project facilities for each of the five action alternatives. Some Project features/facilities and operations (e.g., reservoir size, overhead power line alignments, provision of water for local uses) differ by alternative, and are evaluated in detail within each of the resource areas chapters. As such, the Authority has evaluated all potential impacts with each feature individually, and may choose to select or combine individual features as determined necessary."

Impacts associated with the construction, operation, and maintenance for Alternative C_1 would be the same as Alternative C and are therefore not discussed separately below.

16.3.2.1 Assumptions

The following assumptions were made regarding Project-related construction, operation, and maintenance impacts to geologic, mineral, soil, and paleontological resources:

- Direct Project-related construction, operation, and maintenance activities would occur in the Primary Study Area.
- Direct Project-related operational effects would occur in the Secondary Study Area.
- The only direct Project-related construction activity that would occur in the Secondary Study Area is the installation of two additional pumps into existing bays at the Red Bluff Pumping Plant.
- The only direct Project-related maintenance activity that would occur in the Secondary Study Area is the sediment removal and disposal at the two intake locations (i.e., GCID Main Canal Intake and Red Bluff Pumping Plant).

- No direct Project-related construction or maintenance activities would occur in the Extended Study Area.
- Direct Project-related operational effects that would occur in the Extended Study Area are related to San Luis Reservoir operation; increased reliability of water supply to agricultural, municipal, and industrial water users; and the provision of an alternate Level 4 wildlife refuge water supply. Indirect effects to the operation of certain facilities that are located in the Extended Study Area, and indirect effects to the consequent water deliveries made by those facilities, would occur as a result of implementing the Project alternatives.
- The existing bank protection located upstream of the proposed Delevan Pipeline Intake/Discharge Facilities would continue to be maintained and remain functional.
- No additional channel stabilization, grade control measures, or dredging in the Sacramento River at or upstream of the Delevan Pipeline Intake/Discharge Facilities would be required.
- Erosion is the wearing away of soil and rock by processes such as mechanical or chemical weathering, mass wasting, and the action of waves, wind, and underground water. Excessive soil erosion can eventually lead to damage of building foundations and roadways. At the Project facility sites, areas that are susceptible to erosion are those that would be exposed during the construction phase and along the reservoir shoreline where soil is subjected to wave action. Typically, the soil erosion potential is reduced once the soil is graded and covered with concrete, structures, asphalt, or slope protection. However, some runoff and soil erosion may occur at discharge points from covered areas.

Effects to paleontological resources would only occur during disturbance of fossil-bearing geologic units, which are typically associated with the construction phase of any project. No impacts would occur during Project operation activities or maintenance of Project facilities because no excavations within fossil-bearing geologic units would occur in association with operations or maintenance activities. Maintenance for several of the Project components would include dredging of built-up sediment, but such excavation activities would not affect paleontologically sensitive sediment. Paleontological resources are considered to be affected only if they are removed from the sediment or otherwise mechanically damaged, which would only occur during excavations during the Project construction phase.

16.3.2.2 Methodology

Existing conditions and the future No Project/No Action alternatives were assumed to be similar in the Primary Study Area given the generally rural nature of the area and limited potential for growth and development in Glenn and Colusa counties within the 2030 study period used for this EIR/EIS as further described in Chapter 2 Alternatives Analysis. As a result, within the Primary Study Area, it is anticipated that the No Project/No Action Alternative would not entail material changes in conditions as compared to the existing conditions baseline.

With respect to the Extended and Secondary study areas, the effects of the proposed action alternatives would be primarily related to changes to available water supplies in the Extended and Secondary study areas and the Project's cooperative operations with other existing large reservoirs in the Sacramento watershed, and the resultant potential impacts and benefits to biological resources, land use, recreation, socioeconomic conditions, and other resource areas. The California Department of Water Resources has projected future water demands through 2030 conditions that assume the vast majority of CVP and SWP water contractors would use their total contract amounts, and that most senior water rights users also would fully use most of their water rights. This increased demand in addition to the projects currently under construction and those that have received approvals and permits at the time of preparation of the

EIR/EIS would constitute the No Project/No Action Condition. As described in Chapter 2 Alternative Analysis, the primary difference in these projected water demands would be in the Sacramento Valley; and as of the time of preparation of this EIR/EIS, the water demands have expanded to the levels projected to be achieved on or before 2030.

Accordingly, existing conditions and the No Project/No Action alternatives are assumed to be the same for this EIR/EIS and as such are referred to as the Existing Conditions/No Project/No Action Condition, which is further discussed in Chapter 2 Alternatives Analysis. With respect to applicable reasonably foreseeable plans, projects, programs and policies that may be implemented in the future but that have not yet been approved, these are included as part of the analysis of cumulative impacts in Chapter 35 Cumulative Impacts.

A combination of data, published reports, and professional experience with initial investigations for the Sites Reservoir Project was used to evaluate the Project alternatives for potential impacts due to geology, soils, and minerals. The Extended and Secondary study area impact assessments primarily relied on data and publications (both printed and web-based) from the CGS and the United States Geological Survey. Professional experience with initial investigations included geological mapping within the Primary Study Area and core-drilling at the proposed dam sites.

Expansive soils are characterized by a shrink-swell characteristic.[12] Expansive soils are largely comprised of clays, which expand in volume when water is absorbed and shrink when dried. Soil materials at the Project facility sites are composed of a wide variety of soil types. Using the NRCS Soil Data Viewer, the shrink-swell potential was derived for all of the soil types present at Project facility sites.

The SVP Standard Procedures for the Assessment and Mitigation of Adverse Impacts to Paleontological Resources (SVP, 2010) provide guidelines that establish standard methods for assessing potential impacts to fossils and mitigating these impacts. For the paleontological resources impacts assessment, the paleontological sensitivity and distribution of rock units (including unconsolidated sediments), established during the analysis of the existing environment (refer to Appendix 16C Results of the Paleontological Resources Literature Review), within the impacts area was considered, as well as the type of excavation or other subsurface disturbance. The features of the Project were laid out on a map showing the distribution of rocks having varying paleontological sensitivity. Impacts were identified for those Project facilities that have the potential to cross units of varying paleontological sensitivity (high, moderate, unknown, low, or no sensitivity).

16.3.3 Topics Eliminated from Further Analytical Consideration

No Project facilities or topics that are included in the significance criteria listed above for geology, soils, or minerals were eliminated from further consideration in this chapter.

Within the Primary Study Area, operation and maintenance activities associated with Project facilities would not require excavations; the impacts of these activities are, therefore, not discussed for paleontological resources.

[12] "Shrink-swell" is the cyclical expansion and contraction that occurs in fine-grained clay sediments from wetting and drying. Structures located on soils with this characteristic may be damaged over a long period of time, usually as the result of inadequate foundation engineering or the placement of structures directly on expansive soils.

16.3.4 Impacts Associated with Alternative A

16.3.4.1 Geology and Soils

Extended Study Area – Alternative A

Construction, Operation, and Maintenance Impacts

Agricultural Water Use, Municipal and Industrial Water Use, Wildlife Refuge Water Use, and San Luis Reservoir

Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance

Because there would be no direct Project-related construction or maintenance activities occurring in the Extended Study Area, there would be no increase in the risk of geologic or soils hazards to people or structures in the Extended Study Area, when compared to the Existing Conditions/No Project/No Action Condition. Operation of the Project would result in increased water level fluctuations at the San Luis Reservoir and increased reliability of water to agricultural, municipal and industrial water users, and an alternate supply to wildlife refuge users; these water delivery operations would not affect geology or soils. Alternative A would result in **no impact** to geology or soils or in the Extended Study Area, when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil

Refer to the **Impact Geo/Soils-1** discussion as it relates to the Extended Study Area. That discussion is also applicable to effects on soil erosion and loss of topsoil.

Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil

Refer to the **Impact Geo/Soils-1** discussion as it relates to the Extended Study Area. San Luis Reservoir experiences water level fluctuations; changing those would not affect the soils underlying the reservoir. Increased water reliability to agricultural, municipal and industrial water users, and an alternate supply to wildlife refuge users in the Extended Study Area would not affect underlying soils. Therefore, there would be **no impact** to geology or soils, when compared to the Existing Conditions/No Project/No Action Condition.

No Action/No Project Secondary Study Area – Alternative A

Construction, Operation, and Maintenance Impacts

Trinity Lake, Lewiston Lake, Trinity River, Klamath River downstream of the Trinity River, Whiskeytown Lake, Spring Creek, Shasta Lake, Sacramento River, Keswick Reservoir, Clear Creek, Lake Oroville, Thermalito Complex, Feather River, Sutter Bypass, Yolo Bypass, Folsom

Lake, Lake Natoma, American River, Sacramento-San Joaquin Delta, Suisun Bay, San Pablo Bay, and San Francisco Bay

Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance

Direct Project-related construction that would occur in the Secondary Study Area includes the installation of two additional pumps into existing bays at the Red Bluff Pumping Plant. Installation of the pumps would not disturb any ground because the work would be completed within the existing pumping plant structure.

Direct Project-related operational activities in the Secondary Study Area include the larger reservoirs having more stable water levels (i.e., would not fluctuate as widely) and altered discharge flows in downstream waterways. The only direct Project-related maintenance activity that would occur is the removal of sediment from the existing canal intakes. The sediment settles out of the river water onto the existing canal intake structures and occurs at a rate dependent upon the velocity of the water passing through the intake. The amount of required sediment removal could change if flow rates into the canals change, but modification of existing sediment management activities is not anticipated. Because these Project-related activities in the Secondary Study Area are not expected to result in an increase in geologic or soils hazards to people or structures, **no impact** to geology or soils is expected, when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil

Refer to the **Impact Geo/Soils-1** discussion for the scope of project activities in the Secondary Study Area. Because the Project-related activities would not disturb any ground or change runoff or drainage patterns, **no impact** on soil erosion or loss of topsoil is expected, when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil

Refer to the **Impact Geo/Soils-1** discussion for the scope of project activities in the Secondary Study Area. The Red Bluff Pumping Plant is located on soils that have a low shrink/swell capacity. Therefore, **no impact** to geology or soils is expected, when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that Are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers Are Not Available for the Wastewater Disposal

The Project does not include a septic tank, alternative wastewater disposal system, or sewer system that would be constructed, operated, or maintained in the Secondary Study Area; therefore, there would be **no impact** to geology or soils, when compared to the Existing Conditions/No Project/No Action Condition.

Primary Study Area – Alternative A

Sites Reservoir Complex

Construction, Operation, and Maintenance Impacts

Sites Reservoir Inundation Area (1.3 MAF)

Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance

Only the surface of the ground would be disturbed in the reservoir inundation area, which would not cause the ground to become unstable. The fundamental geology and soil units in the Sites Reservoir Inundation Area would remain unchanged with construction, operation, and maintenance of the Project facilities, therefore there would be **no impact**, when compared to the Existing Conditions/No Project/ No Action Condition.

Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil

During the construction phase, clearing and grubbing activities would occur. Demolition of existing structures and removal of asphalt and fencing would also occur. In addition, temporary access roads would be constructed within the reservoir footprint. These activities could result in an increase of soil erosion within the reservoir footprint. However, with implementation of environmental commitments proposed in Chapter 3 Description of the Sites Reservoir Project Alternatives, specifically related to soil erosion, would reduce the potential release of hazardous materials during construction, operation, or maintenance activities to a **less-than-significant impact** when compared to the Existing Conditions/ No Project/No Action Condition.

During Project operation, reservoir water surface elevations would fluctuate between a minimum of 340 feet and 480 feet. Shoreline erosion would occur along the zone of reservoir water elevation fluctuation and from wave action. **S**ediment delivery into the reservoir resulting from shoreline erosion would be retained within the reservoir and not discharged. Therefore, soil erosion and loss of topsoil during Project operation would be **less than significant.**

Maintenance activities, including garbage removal and maintenance of signs and buoys, would not be expected to result in increased soil erosion. Therefore, there would be **no impact**, when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil

No structures would be constructed within the proposed reservoir inundation area, except for the Sites Reservoir Inlet/Outlet Structure, which is addressed separately. Therefore, construction, operation, and maintenance of the reservoir would result in **no impact**, when compared to the Existing Conditions/ No Project/No Action Condition.

Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that Are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers Are Not Available for the Wastewater Disposal

No septic tanks or alternative wastewater disposal systems would be constructed within the Sites Reservoir Inundation Area. Therefore, construction, operation, and maintenance of the reservoir would result in **no impact**, when compared to the Existing Conditions/No Project/No Action Condition.

Sites Reservoir Dams

Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance

The dams are not located in areas identified as unstable. Geologic investigations would be performed at all dam sites to verify that the foundation can support the dam embankment. Temporary excavations that could be less stable than the existing ground slopes would likely be required to construct the proposed dams. Temporary excavations would be engineered and designed in accordance with state of the practice for excavations and slope stability so that the risk of instability is **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil

The construction of the dams would require the excavation, transport, stockpiling, grading, drilling, blasting, and use of a substantial quantity of bedrock, alluvium, and soil obtained from the borrow areas, and the installation of support structures. Equipment and vehicle staging areas would also be required. Construction activities with the potential for sediment delivery to Funks Creek and Stone Corral Creek include fill placement on the downstream face, and the fill stockpiles downstream of the dam. The soils disturbed by Project earthwork and construction activities, as well as stockpiled materials for use in the construction, would be susceptible to water-induced erosion and loss of topsoil. Construction phase soil erosion could occur, however use of best management practices and environmental commitments proposed in Chapter 3 Description of the Sites Reservoir Project Alternatives during construction, operation, and maintenance activities would result in **less-than-significant impacts**, when compared to the Existing Conditions/No Project/No Action Condition,

During Project operation and maintenance, soil erosion could occur on the newly constructed dams. Erosion control measures described in Chapter 3 Description of the Sites Reservoir Project Alternatives would be incorporated into the dam design to limit erosion. The dams would be faced with rip-rap protection on the reservoir side and vegetation on the landward side. Soil erosion is anticipated to be minimal, resulting in a **less-than-significant impact**, when compared to the Existing Conditions/ No Project/No Action Condition

Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil

Construction of the dams and saddle dams is likely to include excavation of soil down to firm bedrock prior to placement of the dam embankment fill. The expansive soil may be used as clay core material or low permeability material within a zoned dam embankment fill to limit seepage through the dam embankment. Complete excavation of soil would remove the expansion potential of the foundation. Expansive clay used within the dam embankment would be according to an engineered design and would not present a risk to life or property. Therefore, there would be **no impact** related to Project construction, operation, or maintenance, when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that Are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers Are Not Available for the Wastewater Disposal

No septic tanks or alternative wastewater disposal systems would be constructed within the dam sites. Therefore, construction, operation, and maintenance of the dams would result in **no impact**, when compared to the Existing Conditions/No Project/No Action Condition.

Recreation Areas

Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance

Grading of the recreation areas may include minor cut or fill slopes, and any slopes will be engineered for stability. Changes will not be made to the ground that would cause it to become unstable. The fundamental geology and soil units in the Recreation Areas would remain unchanged with construction, operation, and maintenance of the Project facilities, therefore there would be **no impact**, when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil

The construction of the Recreation Areas would require grading, including removal and/or stockpiling of surface soils and some bedrock. During operation, impervious surfaces developed at the recreation areas could increase runoff. Road grading, vegetation control, and fuels management would occur as part of regular maintenance of the recreation areas. These construction, operation, and maintenance activities could increase soil erosion and loss of topsoil. However, these potential impacts would be addressed through the best management practices and environmental conditions proposed in Chapter 3 Description of the Sites Reservoir Project Alternatives, including implementation of a Stormwater Pollution Prevention Plan. Implementation of these plans and commitments would result in **less-than-significant impacts** related to erosion and loss of topsoil.

Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil

Approximately 66 percent (802 acres) of the total area of the proposed Recreation Areas is classified by the NRCS as having a high shrink-swell potential. Impacts from constructing, operating, and maintaining Project facilities on expansive soils within the Recreation Areas could be possible. Geotechnical investigations would be performed to identify appropriate standard design/engineering approaches to limit the risk of adverse effects related to expansive soil. Standard measures, such as water infiltration management, structural stiffening, increased foundation embedment, or over excavation and replacement with suitable material, would be used as applicable. With implementation of standard design measures, impacts would be **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that Are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers Are Not Available for the Wastewater Disposal

The Recreation Areas would have vault toilets, and waste would be transported and disposed of outside of the Primary Study Area. Vault toilets are not considered to be alternative wastewater disposal systems. Therefore, construction, operation, and maintenance would result in **no impact**, when compared to the Existing Conditions/No Project/No Action Condition.

South Bridge and Roads

Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance

Refer to the **Impact Geo/Soils-1** discussion for the Sites Reservoir Inundation Area. That discussion is also applicable to the Road Relocations and South Bridge.

Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil

Construction of the Road Relocations and South Bridge would require grading and cut/fill operations along road footprints and 200-foot construction disturbance area. Slopes may be steepened, leading to increased erosion potential. During Project operation and maintenance, increased runoff from additional impervious road surfaces as well as road maintenance and vegetation removal could increase erosion in local drainages. However, implementation of environmental commitments related to soil erosion proposed in Chapter 3 Description of the Sites Reservoir Project Alternatives, would reduce impacts during construction, operation, or maintenance activities to **less than significant** when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil

More than 50 percent (679 acres) of the total area of the Road Relocations and South Bridge are classified by the NRCS as having a high shrink-swell potential. An additional 125 acres are classified as having a low to high or moderate to high shrink-swell potential. Geotechnical investigations would be performed to identify appropriate standard design/engineering approaches to limit the risk of adverse effects related to expansive soil. Standard measures such as water infiltration management, structural stiffening, increased foundation embedment, or over excavation and replacement with suitable material would be used as applicable. With implementation of standard design measures, impacts would be **less than significant** when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that Are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers Are Not Available for the Wastewater Disposal

No septic tanks or alternative wastewater disposal systems would be constructed, operated, or maintained within the road relocations. Therefore, there would be **no impact**, when compared the Existing Conditions/No Project/No Action Condition.

Sites Pumping/Generating Plant, Sites Electrical Switchyard, Tunnel from the Sites Pumping/Generating Plant to the Sites Reservoir Inlet/Outlet Structure, and Sites Reservoir Inlet/Outlet Structure

Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance

Refer to the **Impact Geo/Soils-1** discussion for the Sites Reservoir Dams. That discussion is also applicable to the Sites Pumping/Generating Plant, Sites Electrical Switchyard, Tunnel from the Sites Pumping/Generating Plant to the Sites Reservoir Inlet/Outlet Structure, and Sites Reservoir Inlet/Outlet Structure.

Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil

Construction of these Project facilities would require the excavation, transport, stockpiling, grading, drilling, blasting. Tunnel construction would require stockpiling of rock spoil removed from the tunnel alignment. Slopes may be steepened leading to increased runoff potential. However, implementation of environmental commitments related to soil erosion proposed in Chapter 3 Description of the Sites Reservoir Project Alternatives, would reduce the potential impacts during construction activities to **less than significant** when compared to the Existing Conditions/No Project/No Action Condition. During Project operation and maintenance, areas would be covered with impervious material or vegetation; additional erosion is anticipated to be minimal, resulting in a **less-than-significant impact**, when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil

Approximately 25 percent (24 acres) of the total area of these combined Project facilities is classified by the NRCS as having a high shrink-swell potential. Impacts from constructing, operating, and maintaining Project facilities on expansive soils within these areas could be possible. Geotechnical investigations would be performed to identify appropriate standard design/engineering approaches to limit the risk of adverse effects related to expansive soil. Standard measures such as water infiltration management, structural stiffening, increased foundation embedment, or over excavation and replacement with suitable material would be used as applicable. With implementation of standard design measures, impacts would be **less than significant** when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that Are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers Are Not Available for the Wastewater Disposal

No Project-related septic tanks or alternative wastewater disposal systems would be constructed, operated, or maintained at these facilities. Therefore, there would be **no impact**, when compared to the Existing Conditions/No Project/No Action Condition.

Field Office Maintenance Yard

Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance

Refer to the **Impact Geo/Soils-1** discussion for the Sites Reservoir Inundation Area. That discussion is also applicable to the Field Office Maintenance Yard.

Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil

The construction of the Field Office Maintenance Yard would require removal of topsoil and possibly some bedrock. Increased erosion could occur during construction, however, implementation of environmental commitments related to soil erosion proposed in Chapter 3 Description of the Sites Reservoir Project Alternatives, would reduce the potential impacts during construction to **less than significant** when compared to the Existing Conditions/No Project/No Action. During Project operation and maintenance, areas would be covered with impervious material or vegetation; additional erosion is anticipated to be minimal, resulting in a **less-than-significant impact**, when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil

Less than 2 percent (0.3 acre) of the total area of the Field Office Maintenance Yard is classified by the NRCS as having a high shrink-swell potential. It is unlikely that the small amount of potentially expansive soil would affect the proposed structures. Appropriate standard design/engineering approaches identified during geotechnical investigations would be implemented. Therefore, Project construction, operation, and maintenance impacts would be **less than significant** when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that Are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers Are Not Available for the Wastewater Disposal

It is anticipated that a septic tank would be located in the vicinity of the Field Office Maintenance Yard. While soils in the vicinity of this Project feature are considered to have “limitations” related to feasibility of septic system operations (i.e., slow percolation, flooding), these limitations can typically be addressed with design and location adjustments. Soil and percolation will be evaluated and the system will be designed to address site specific conditions. If a septic system is found to be infeasible, other approved options such as vault toilets, will be used instead. Impacts are, therefore, considered **less than significant** for construction, operation, and maintenance, when compared to the Existing Conditions/No Project/No Action Condition.

Holthouse Reservoir Complex

Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance

Refer to the **Impact Geo/Soils-1** discussion for the Sites Reservoir Inundation Area. That discussion is also applicable to the Holthouse Reservoir Complex.

Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil

During the dredging of Funks Reservoir, the reservoir itself would be de-watered. Draining and maintenance of the reservoir could lead to increased erosion of exposed reservoir sediments, however the erosion would be contained within the reservoir area, therefore this would be a **less-than-significant impact**, when compared to the Existing Conditions/No Project/No Action Condition.

Construction of the Holthouse Reservoir Complex would require the excavation, transport, stockpiling, grading, drilling, blasting, and use of a moderate quantity of bedrock, alluvium, and soil obtained from the borrow areas. Equipment and vehicle staging areas would also be required. Construction activities with the potential for sediment delivery to Funks Creek include fill placement on the downstream face and the fill stockpiles downstream of the dam. The soils disturbed by Project earthwork and construction activities, as well as stockpiled materials for use in the construction, would be susceptible to water induced erosion and loss of topsoil. However, implementation of environmental commitments related to soil erosion proposed in Chapter 3 Description of the Sites Reservoir Project Alternatives, would reduce the potential impacts during construction activities to a **less-than-significant impact** when compared to the Existing Conditions/No Project/No Action Condition.

During Project operation, reservoir water surface elevations would fluctuate up to 14 feet. Shoreline erosion would occur along the zone of reservoir-elevation fluctuation. Sediment delivery into the reservoir resulting from shoreline erosion would be retained within the reservoir and not discharged. Therefore shoreline soil erosion would be **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition.

Periodic maintenance required for the existing Funks Reservoir includes road, vegetation, and fence maintenance, as well as debris removal, on an as-needed basis. The reservoir is also drained annually. With the exception of annual reservoir draining, which would not be required for the larger reservoir, similar maintenance activities are expected for Holthouse Reservoir. However, implementation of environmental commitments related to soil erosion proposed in Chapter 3 Description of the Sites Reservoir Project Alternatives, would reduce potential impacts during maintenance activities to a **less-than-significant impact** when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil

Nearly 90 percent (324 acres) of the total area of the Holthouse Reservoir Complex is classified by the NRCS as having a high shrink-swell potential. NRCS soil data is not available for the existing Funks Reservoir, however based on NRCS data for the proposed Holthouse Reservoir, and to be conservative, it is assumed that the soils also have a high shrink-swell potential. Impacts from constructing, operating, and maintaining Project facilities on expansive soils within the Holthouse Reservoir Complex could be possible. Geotechnical investigations would be performed to identify appropriate standard design/ engineering approaches to limit the risk of adverse effects related to expansive soil. Standard measures such as water infiltration management, structural stiffening, increased foundation embedment, or over excavation and replacement with suitable material would be used as applicable. With implementation of standard design measures, impacts would be **less than significant** when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that Are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers Are Not Available for the Wastewater Disposal

No septic tanks or alternative wastewater disposal systems would be constructed, operated, or maintained within the Holthouse Reservoir Complex. Therefore, there would be **no impact**, when compared to the Existing Conditions/No Project/No Action Condition.

Terminal Regulating Reservoir, Terminal Regulating Reservoir Pumping/Generating Plant and Electrical Switchyard, Glenn-Colusa Irrigation District Canal Connection to the Terminal Regulating Reservoir, and Glenn-Colusa Irrigation District Canal Facilities Modifications

Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance

Refer to the **Impact Geo/Soils-1** discussion for the Sites Reservoir Inundation Area. That discussion is also applicable to the TRR, TRR Pumping/Generating Plant, TRR Electrical Switchyard, GCID Main Canal Connection to the TRR, and the GCID Main Canal Facilities Modifications.

Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil

The construction of the TRR, GCID Main Canal Connection to the TRR, TRR Pumping/Generating Plant, TRR Electrical Switchyard, as well as the proposed modifications to existing GCID Main Canal Facilities, would require the excavation, transport, stockpiling, grading, and use of a moderate quantity of bedrock, alluvium, and soil obtained from the borrow areas. Increased erosion could occur during Project construction. However, implementation of environmental commitments related to soil erosion proposed in Chapter 3 Description of the Sites Reservoir Project Alternatives, would reduce the potential impacts during construction activities to **less-than-significant impact** when compared to the Existing Conditions/No Project/No Action Condition. During Project operation and maintenance, areas would be covered with impervious material or vegetation; additional erosion is anticipated to be minimal, resulting in a **less-than-significant impact**, when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil

All soils at these facilities are classified by the NRCS as having a high shrink-swell potential. Impacts from constructing, operating, and maintaining Project facilities on expansive soils within the TRR Complex could be possible. Geotechnical investigations would be performed to identify appropriate standard design/engineering approaches to limit the risk of adverse effects related to expansive soil. Standard measures such as water infiltration management, structural stiffening, increased foundation embedment, or over excavation and replacement with suitable material would be used as applicable. With implementation of standard design measures, impacts would be **less than significant** when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that Are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers Are Not Available for the Wastewater Disposal

The TRR Pumping/Generating Plant would have portable toilets, and waste would be transported and disposed of outside of the Primary Study Area. Portable toilets are not considered to be alternative wastewater disposal systems. Therefore, construction, operation, and maintenance would result in **no impact**, when compared to the Existing Conditions/No Project/No Action Condition.

Sites/Delevan Overhead Power Line

Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance

Refer to the **Impact Geo/Soils-1** discussion for the Sites Reservoir Inundation Area. That discussion is also applicable to the Sites/Delevan Overhead Power Line.

Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil

The construction of the Sites/Delevan Overhead Power Line would require the construction of a temporary access road along the alignment and soil excavation for tower footings. During Project construction, erosion could occur, however, implementation of environmental commitments related to soil erosion proposed in Chapter 3 Description of the Sites Reservoir Project Alternatives, would reduce the potential impacts during construction activities to **less-than-significant impact** when compared to the Existing Conditions/No Project/No Action Condition. Project operation would be an unmanned activity. Maintenance activities, including equipment inspections and vegetation maintenance, are expected to cause minimal soil erosion. Therefore, operation and maintenance would result in a **less-than-significant impact**, when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil

The Sites/Delevan Overhead Power Line alignment traverses soils that are classified by the NRCS as having a high shrink-swell potential. Impacts from constructing, operating, and maintaining Project facilities on expansive soils within the Sites/Delevan Overhead Power Line alignment could be possible. Geotechnical investigations would be performed to identify appropriate standard design/engineering approaches to limit the risk of adverse effects related to expansive soil. Standard measures such as water infiltration management, structural stiffening, increased foundation embedment, or over excavation and replacement with suitable material would be used as applicable. With implementation of standard design measures, impacts would be **less than significant** when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that Are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers Are Not Available for the Wastewater Disposal

No Project-related septic tanks or alternative wastewater disposal systems would be constructed, operated, or maintained along the Sites/Delevan Overhead Power Line. Therefore, there would be **no impact**, when compared to the Existing Conditions/No Project/No Action Condition.

Delevan Pipeline, Terminal Regulating Reservoir Pipeline, Terminal Regulating Reservoir Pipeline Road

Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance

Refer to the **Impact Geo/Soils-1** discussion for the Sites Reservoir Inundation Area. That discussion is also applicable to the Delevan Pipeline, TRR Pipeline, and the TRR Pipeline Road. Topsoil removed during the cut-and-cover installation of the pipeline would be stockpiled for reuse to minimize the loss of topsoil, resulting in a **less-than-significant impact**, when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil

Construction of the Delevan Pipeline and TRR Pipeline would require dewatering, as well as trenching of soils and alluvial material down to the design depth. The excess materials could be distributed on a 750-foot-wide strip on either side of the pipelines' alignment. Construction of the TRR Pipeline Road would also result in ground disturbance. However, during the construction period additional erosion is anticipated to be minimal because the terrain is flat and generally surrounded by rice checks, resulting in a **less-than-significant impact**, when compared to the Existing Conditions/No Project/No Action Condition.

During Project operation, because the pipelines would be buried and operated remotely, no additional erosion impacts are anticipated, resulting in **no impact**, when compared to the Existing Conditions/No Project/No Action Condition. Periodic maintenance inspections would not cause additional erosion impacts, resulting in **no impact**, when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil

More than 80 percent (176 acres) of the total area of these Project features is classified by the NRCS as having a high shrink-swell potential. Impacts from constructing, operating, and maintaining Project facilities on expansive soils for these project facilities could be possible. Geotechnical investigations would be performed to identify appropriate standard design/engineering approaches to limit the risk of adverse effects related to expansive soil. Standard measures such as water infiltration management, structural stiffening, increased foundation embedment, or over excavation and replacement with suitable material would be used as applicable. With implementation of standard design measures, impacts would be **less than significant** when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that Are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers Are Not Available for the Wastewater Disposal

No Project-related septic tanks or alternative wastewater disposal systems would be constructed, operated, or maintained along the Delevan Pipeline, TRR Pipeline, or TRR Pipeline Road. Therefore, there would be **no impact**, when compared to the Existing Conditions/No Project/No Action Condition.

Delevan Pipeline Intake/Discharge Facilities

Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance

Refer to the **Impact Geo/Soils-1** discussion for the Sites Reservoir Dams. That discussion is also applicable to the Delevan Pipeline Intake/Discharge Facilities.

Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil

The construction of the Delevan Pipeline Intake/Discharge Facilities would require dewatering; clearing and grading the construction workspace; excavating soils and alluvium from the forebay, afterbay, and pumping plant sites; and filling and re-grading where needed. During the construction period, additional erosion could occur. However, implementation of environmental commitments related to soil erosion proposed in Chapter 3 Description of the Sites Reservoir Project Alternatives, would reduce the potential impacts during construction, operation, or maintenance activities to **less-than-significant impact** when compared to the Existing Conditions/No Project/No Action Condition. During Project operation and maintenance, areas would be covered with impervious material or vegetation; no additional erosion impacts are anticipated, resulting in **no impact**, when compared to the Existing Conditions/No Project/ No Action Condition.

Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil

All soil at this Project feature location is classified by the NRCS as having a low shrink-swell potential. Construction, operation, and maintenance impacts are, therefore, considered **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that Are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers Are Not Available for the Wastewater Disposal

The Delevan Pipeline Intake/Discharge Facilities would have portable toilets, and waste would be transported and disposed of outside of the Primary Study Area. Portable toilets are not considered to be alternative wastewater disposal systems. Therefore, construction, operation, and maintenance would result in **no impact**, when compared to the Existing Conditions/No Project/No Action Condition.

Project Buffer

Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance

Refer to the **Impact Geo/Soils-1** discussion for the Sites Reservoir Inundation Area. That discussion is also applicable to the Project Buffer.

Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil

During Project construction, existing structures within the Project Buffer would be demolished and fences would be constructed. A fuel break would also be constructed, operated, and maintained within the

Project Buffer. These activities could cause a temporary increase in soil erosion. Implementation of environmental commitments related to soil erosion proposed in Chapter 3 Description of the Sites Reservoir Project Alternatives, would reduce the potential impacts during construction, operation, or maintenance activities to **less than significant** when compared to the Existing Conditions/No Project/ No Action Condition.

Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil

No structures would be constructed within the Project Buffer. Therefore, there would be **no impact**, when compared to the Existing Conditions/No Project/No Action Condition.

Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that Are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers Are Not Available for the Wastewater Disposal

No Project-related septic tanks or alternative wastewater disposal systems would be constructed within the Project Buffer. Therefore, there would be **no impact**, when compared to the Existing Conditions/ No Project/No Action Condition.

16.3.4.2 Minerals

Extended and Secondary Study Areas – Alternative A

Construction, Operation, and Maintenance Impacts

Agricultural Water Use, Municipal and Industrial Water Use, Wildlife Refuge Water Use, and San Luis Reservoir, Trinity Lake, Lewiston Lake, Trinity River, Klamath River downstream of the Trinity River, Whiskeytown Lake, Spring Creek, Shasta Lake, Sacramento River, Keswick Reservoir, Clear Creek, Lake Oroville, Thermalito Complex (Thermalito Diversion Pool, Thermalito Forebay, and Thermalito Afterbay); Feather River; Sutter Bypass; Yolo Bypass; Folsom Lake; Lake Natoma; American River; Sacramento-San Joaquin Delta; Suisun Bay; San Pablo Bay; and San Francisco Bay

Impact Min-1: Loss of Availability of a Known Mineral Resource that Would Be of Value to the Region and the Residents of the State

Aggregate minerals resources from within or nearby the Sites Reservoir Inundation Area as well as several commercially available sources would be used for the Sites Reservoir Project. No mineral resources are required to operate and maintain the Project. Therefore, construction, operation, and maintenance of Alternative A would not result in the loss of availability of any known important mineral resource, or interfere with any existing commercial mining activity, resulting in a **less-than-significant impact** on mineral resources in the Extended and Secondary study areas, when compared to the Existing Conditions /No Project/No Action Condition.

Project operation (including operation of San Luis Reservoir) would not require mineral resources, resulting in **no impact** on mineral resources. In addition, the pump installation, operation, and maintenance at the Red Bluff Pumping Plant would not require mineral resources, resulting in **no impact**, when compared to the Existing Conditions/No Project/No Action Condition.

Impact Min-2: Loss of Availability of a Locally Important Mineral Resource Recovery Site Delineated on a Local General Plan, Specific Plan, or Other Land Use Plan

Refer to the **Impact Min-1** discussion. That discussion is also applicable to locally important mineral resource recovery sites.

Impact Min-3: Expose People to Naturally Occurring Asbestos during Project Construction, Operation, or Maintenance

Ultramafic rocks containing naturally occurring asbestos would not be disturbed during Project construction, operation, or maintenance within the Extended and Secondary study areas. Therefore, Alternative A would result in **no impact**, when compared to the Existing Conditions/No Project/ No Action Condition.

Primary Study Area – Alternative A

Construction, Operation, and Maintenance Impacts

All Primary Study Area Project Facilities

Impact Min-1: Loss of Availability of a Known Mineral Resource that Would Be of Value to the Region and the Residents of the State

Aggregate minerals resources from within or nearby the Sites Reservoir Inundation Area as well as several commercially available sources would be used for the Sites Reservoir Project. No mineral resources are required to operate or maintain the Project. Therefore, construction, operation, and maintenance of Alternative A would not result in the loss of availability of any known mineral resource, or interfere with any existing commercial mining activity, resulting in **less-than-significant impact** on mineral resources, when compared to the Existing Conditions/No Project/No Action Condition.

Impact Min-2: Loss of Availability of a Locally Important Mineral Resource Recovery Site Delineated on a Local General Plan, Specific Plan, or Other Land Use Plan

Refer to the **Impact Min-1** discussion. That discussion is also applicable to mineral resource recovery sites.

Impact Min-3: Expose People to Naturally Occurring Asbestos during Project Construction, Operation, or Maintenance

Ultramafic rocks that may contain naturally occurring asbestos are mapped near the west edge of the Primary Study Area. However, these rocks would not be disturbed during Project construction, operation, or maintenance. Ultramafic rocks are not present in the Sites Reservoir inundation or buffer area, nor are they present in the watershed draining into the reservoir. Therefore, construction, operation, and maintenance activities associated with Alternative A would not expose people to naturally occurring asbestos, resulting in **no impact**, when compared to the Existing Conditions/No Project/No Action Condition.

16.3.4.3 Paleontology

Extended Study Area – Alternative A

Construction, Operation, and Maintenance Impacts

Agricultural Water Use, Municipal and Industrial Water Use, Wildlife Refuge Water Use, and San Luis Reservoir

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

Because there would be no direct Project-related construction or maintenance occurring in the Extended Study Area, no paleontologically sensitive sediments would be disturbed. Therefore, there would be **no impact** to paleontological resources in the Extended Study Area, when compared to the Existing Conditions/No Project/No Action Condition.

Secondary Study Area – Alternative A

Construction, Operation, and Maintenance Impacts

Trinity Lake, Lewiston Lake, Trinity River, Klamath River downstream of the Trinity River, Whiskeytown Lake, Spring Creek, Shasta Lake, Sacramento River, Keswick Reservoir, Clear Creek, Lake Oroville, Thermalito Complex (Thermalito Diversion Pool, Thermalito Forebay, and Thermalito Afterbay); Feather River; Sutter Bypass; Yolo Bypass; Folsom Lake; Lake Natoma; American River; Sacramento-San Joaquin Delta; Suisun Bay; San Pablo Bay; and San Francisco Bay

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

The only direct Project-related construction that would occur in the Secondary Study Area is the installation of two additional pumps into existing bays at the Red Bluff Pumping Plant. The only direct Project-related maintenance activity that would occur would be the removal of sediment from the existing canal intakes. Because neither of these Project-related activities in the Secondary Study Area is expected to affect paleontologically sensitive sediment, **no impact** to paleontological resources is expected, when compared to the Existing Conditions/No Project/No Action Condition.

Primary Study Area – Alternative A

Construction, Operation, and Maintenance Impacts

Sites Reservoir Inundation Area (1.3 MAF)

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

Inundation would not affect paleontological resources; however, excavations (borrow pits and other similar facilities) may occur within the reservoir inundation area. Thus, construction of the 1.3-MAF reservoir would affect rocks of the GVS, including the low sensitivity Boxer Formation and, to a lesser extent, the low to moderate sensitivity Cortina Formation, as well as low sensitivity Quaternary alluvium predominantly located within stream channels. Excavation within the potentially fossiliferous sediments of the GVS within the reservoir footprint would result in a **potentially significant impact** to paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

Sites Reservoir Dams

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

Construction of the footings and anchor walls for Golden Gate Dam and Sites Dam would involve deep excavation into potentially fossiliferous sediments of the GVS. The construction of Golden Gate and Sites dams would predominantly affect the moderate sensitivity Venado Sandstone of the Cortina Formation, and to a lesser extent the low sensitivity Boxer Formation. In addition, the seven saddle dams on the rim of the 1.3-MAF reservoir would affect the Boxer Formation and overlying low sensitivity basin fill. Because these saddle dam excavations would be shallower and of more limited extent than for Golden Gate and Sites dams, the impacts from construction of the saddle dams would be less than those associated with the larger Sites and Golden Gate dams. The deep excavation into potentially fossiliferous members of the GVS, as well as construction activities within other moderately sensitive rock units associated with dam construction, would result in a **potentially significant impact** to paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

Recreation Areas

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

The recreation areas would be constructed predominantly on the rim of the Sites Reservoir inundation area, and would affect the low sensitivity Boxer Formation, the low- to moderate-sensitivity Cortina Formation, and low sensitivity Quaternary alluvium. Construction of the Antelope Island Recreation Area, which would be located within the reservoir, would only impact the Boxer Formation and basin fill (for this analysis, it is considered the same as Quaternary alluvium). Recreation Area construction activities within the potentially fossiliferous member of the GVS would result in a **potentially significant impact** on paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

Road Relocations and South Bridge

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

Similar to the recreation areas, the road relocations would occur predominantly on the rim of and within the inundation area, and in the case of the South Bridge, within the inundation area. Construction associated with these features would affect the low sensitivity Boxer Formation, the low- to moderate-sensitivity Cortina Formation, and low sensitivity Quaternary alluvium. Road construction activities within the potentially fossiliferous member of the GVS would result in a **potentially significant impact** on paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

Sites Pumping/Generating Plant and Sites Electrical Switchyard

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

The Sites Pumping/Generating Plant and its associated switchyard would be located on the eastern margin of the Sites Reservoir, immediately south of the Golden Gate Dam. Project construction would affect the low- to moderate-sensitivity Cortina Formation and a thin veneer of low sensitivity Quaternary alluvium. Construction activities within the potentially fossiliferous member of the GVS associated with construction of these facilities would result in a **potentially significant impact** on paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

Tunnel from Sites Pumping/Generating Plant to Sites Reservoir Inlet/Outlet Structure

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

This tunnel would extend through the low sensitivity Boxer Formation to the west and the low- to moderate-sensitivity Cortina Formation to the east. Low sensitivity Quaternary alluvium would be impacted at both ends of the tunnel. Construction activities within the potentially fossiliferous member of the GVS associated with construction of the tunnel would result in a **potentially significant impact** on paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

Sites Reservoir Inlet/Outlet Structure

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

The Sites Reservoir Inlet/Outlet Structure would affect the low sensitivity Boxer Formation and low sensitivity Quaternary alluvium within the inundation area, and would affect the low- to moderate-sensitivity Cortina Formation and low sensitivity basin fill east of the inundation area. Construction activities within the potentially fossiliferous member of the GVS associated with construction of the Inlet/Outlet Structure would result in a **potentially significant impact** on paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

Field Office Maintenance Yard

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

The Field Office Maintenance Yard would affect the low- to moderate-sensitivity Cortina Formation and low sensitivity basin fill, resulting in a **potentially significant impact** on paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

Holthouse Reservoir Complex

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

Funks Reservoir is located east of the Sites Reservoir, on low sensitivity basin deposits underlain by the moderate sensitivity Sites and Yolo members of the Cortina Formation. Dredging is not likely to affect these formations because most reservoirs build up a layer of sediment over time and dredging would be directed at removing that recent accumulation of sediment. Because this sediment has been deposited since the last (historic-era) dredging, sediment dredging would have **no impact** on paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

The Holthouse Reservoir Complex would be located adjacent to the existing Funks Reservoir, within the Sacramento Valley. Similar to that described for Sites Reservoir, the inundation of Holthouse Reservoir would not impact paleontological resources, but excavations within the inundation area and excavations associated with the dam construction would impact paleontologically sensitive geologic units. Construction of these features would affect low sensitivity basin fill and, at depth, the moderate sensitivity Riverbank Formation. Excavation and other construction activities associated with the Holthouse Reservoir Complex within the moderate sensitivity Riverbank Formation would result in a **potentially significant impact** to paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

Glenn-Colusa Irrigation District Canal Facilities Modifications

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

The majority of the construction associated with the existing GCID Main Canal consists of repairs or refurbishments, and would only affect previously disturbed sediment, which has a low paleontological sensitivity. Any excavations that extend beyond previously disturbed soil would affect the moderate sensitivity Modesto and Riverbank formations. Due to the possibility of disturbance to moderate sensitivity formations, construction activities associated with modifications to the GCID Main Canal would result in a **potentially significant impact** on paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

Terminal Regulating Reservoir and Glenn-Colusa Irrigation District Canal Connection to the Terminal Regulating Reservoir

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

Similar to the discussion for Sites and Holthouse reservoirs, the inundation of the TRR would not affect paleontological resources. However, excavation within the inundation area may occur, and excavations for dams and other structures around the rim of the inundation area would affect paleontologically sensitive units. The TRR would be located within the Sacramento Valley, and excavations associated with this reservoir would impact the moderate sensitivity Riverbank Formation and low sensitivity basin fill.

Construction associated with the connection to the GCID Main Canal would include the excavation of a canal energy dissipation bay with check structure, the inlet channel to the TRR, and the inlet control structure. These excavations would impact the moderate sensitivity Riverbank Formation and low sensitivity basin fill. Construction activities associated with these facilities within moderate sensitivity formations would result in a **potentially significant impact** on paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

Terminal Regulating Reservoir Pumping/Generating Plant and Terminal Regulating Reservoir Electrical Switchyard

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

Excavations associated with this pumping/generating plant and electrical switchyard, which would be located at the rim of the TRR, would impact the moderate sensitivity Riverbank Formation and low sensitivity basin fill. Construction activities associated with these facilities within a moderate sensitivity formation would result in a **potentially significant impact** on paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

Terminal Regulating Reservoir Pipeline and Terminal Regulating Reservoir Pipeline Road,

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

Construction of the TRR Pipeline and TRR Pipeline Road, would affect the low- to moderate-sensitivity Cortina Formation and low-sensitivity basin fill. Construction activities within the potentially fossiliferous member of the GVS associated with construction of the TRR Pipeline and TRR Pipeline Road, would result in a **potentially significant impact** on paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

Sites/Delevan Overhead Power Line

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

The Sites/Delevan Overhead Power Line would affect the low- to moderate-sensitivity Cortina Formation and low sensitivity basin fill between the Sites Pumping/Generating Plant and the existing Western Area Power Administration (WAPA) or Pacific Gas and Electric Company (PG&E) transmission line, and low sensitivity Quaternary alluvium and basin deposits, the moderate sensitivity Modesto Formation, the moderate sensitivity Riverbank Formation, and the low- to moderate-sensitivity Cortina Formation between the existing WAPA or PG&E transmission line and the Sacramento River. Construction activities associated with placement of the overhead power line tower footings within the potentially fossiliferous member of the GVS, or within moderate sensitivity formations, would result in a **potentially significant impact** to paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

Delevan Pipeline

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

The Delevan Pipeline would parallel the east to west aligned Sites/Delevan Overhead Power Line, and along its entire length would affect the same geologic units: low sensitivity Quaternary alluvium and basin deposits, the moderate sensitivity Modesto Formation, the moderate sensitivity Riverbank Formation, and the low- to moderate-sensitivity Cortina Formation. Construction activities associated with the Delevan Pipeline within the potentially fossiliferous member of the GVS, or within moderate sensitivity formations, would result in a **potentially significant impact** to paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

Delevan Pipeline Intake/Discharge Facilities

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

Geologic units that would be affected by construction of the Delevan Pipeline Intake/Discharge Facilities consist of low sensitivity Quaternary alluvium deposited by the Sacramento River and the underlying moderate sensitivity Modesto Formation and high sensitivity Tehama Formation. Construction activities associated with the Delevan Pipeline Intake/Discharge Facilities, within moderate and high sensitivity formations, would result in a **potentially significant impact** to paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

Project Buffer

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

Excavations associated with the demolition of existing structures would be limited to previously disturbed sediments of no paleontological sensitivity, and the installation of fencing and creation of a fuelbreak would not involve excavations, and therefore, would not impact paleontological resources. Construction activities associated with the Project Buffer would, therefore, have **no impact** on paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

16.3.5 Impacts Associated with Alternative B

16.3.5.1 Geology and Soils

Extended and Secondary Study Areas – Alternative B

Construction, Operation, and Maintenance Impacts

The impacts associated with Alternative B, as they relate to geology and soils (**Impact Geo/Soils-1**), soil erosion and loss of topsoil (**Impact Geo/Soils-2**), the level of risk to life and property from activities on expansive soil (**Impact Geo/Soils-3**), and soils that are incapable of supporting septic tanks or alternative wastewater disposal systems (**Impact Geo/Soils-4**), would be the same as described for Alternative A for the Extended and Secondary study areas.

Primary Study Area – Alternative B

Construction, Operation, and Maintenance Impacts

Many Project facilities would be the same for Alternatives A and B (see Table 3-1, Chapter 3 Description of the Sites Reservoir Project Alternatives. These facilities would require the same construction methods and operation and maintenance activities regardless of Project alternative, and would, therefore, result in the same construction, operation, and maintenance impacts to geology and soils. Unless explicitly discussed below, impacts at all Project facilities are anticipated to be the same as previously discussed for Alternative A.

The boundary of the Project Buffer would be the same for Alternatives A and B, but because the footprints of some of the Project facilities that are surrounded by the Project Buffer would differ between the Project alternatives, the acreage of land within the Project Buffer would also differ. However, this difference in the size of the area included within the buffer would not change the type of construction, operation, and maintenance activities that were described for Alternative A. It would, therefore, have the same impact on geology and soils (**Impact Geo/Soils-1**), soil erosion and loss of topsoil (**Impact Geo/Soils-2**), the level of risk to life and property from activities on expansive soil (**Impact Geo/Soils-3**), and soils that are incapable of supporting septic tanks or alternative wastewater disposal systems (**Impact Geo/Soils-4**), as described for Alternative A.

If Alternative B is implemented, the footprint or construction disturbance area of Sites Reservoir and Dams, the Road Relocations and South Bridge, and the Sites/Delevan Overhead Power Line would differ from Alternative A. In addition, the Delevan Pipeline Intake/Discharge Facilities would be replaced by a discharge-only facility. Impacts due to geology and soils (**Impact Geo/Soils-1**), the level of risk to life and property from activities on expansive soil (**Impact Geo/Soils-3**), and soils that are incapable of supporting septic tanks or alternative wastewater disposal systems (**Impact Geo/Soils-4**) would be the same for Alternative B as was described for Alternative A. The effects of operation and maintenance activities associated with these facilities on soil erosion would be the same as described for Alternative A. The differences in the effects of construction activities between Project alternatives relative to soil erosion are described below.

Sites Reservoir Inundation Area (1.8 MAF)

Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil

During Project operation, reservoir surface elevations would fluctuate between a minimum of 340 feet and 520 feet. Shoreline erosion would occur along the zone of reservoir-elevation fluctuation and would have a greater impact than Alternative A because a greater surface area would be exposed to wave action and associated erosion. Similar to that described for Alternative A, sediment delivery into the reservoir resulting from shoreline erosion would be retained within the reservoir, therefore soil erosion impacts from Project construction, operation, and maintenance would be **less than significant**, when compared to the Existing Conditions/No Project/No Action Condition.

Sites Reservoir Dams

Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil

Construction erosion impacts associated with Alternative B would be similar to those described for Alternative A. However, because of the total of nine saddle dams with Alternative B (compared to seven with Alternative A), and larger footprints for Sites and Golden Gate dams, overall construction erosion impacts associated with the Alternative B dams would increase, however, the increased soil erosion would still be addressed though implementation of the environmental commitments proposed in Chapter 3 Description of the Sites Reservoir Project Alternatives. Potential impacts during construction, operation, or maintenance activities would be reduced to **less than significant** when compared to the Existing Conditions/No Project/No Action Condition.

Delevan Pipeline Discharge Facilities

Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil

The footprint of the Delevan Pipeline Discharge Facility included in Alternative B would be less than half the size of the Delevan Pipeline Intake/Discharge Facilities described for Alternative A; therefore, construction erosion impacts associated with this facility would be less than that described for Alternative A and with implementation of the environmental commitments, would result in a **less-than-significant impact**, when compared to the Existing Conditions/No Project/No Action Condition.

16.3.5.2 Minerals

Extended, Secondary, and Primary Study Areas – Alternative B

Construction, Operation, and Maintenance Impacts

The impacts associated with Alternative B, as they relate to known mineral resources of value (**Impact Min-1**), locally important resources (**Impact Min-2**), and naturally occurring asbestos (**Impact Min-3**), would be the same as described for Alternative A for the Extended, Secondary, and Primary study areas.

16.3.5.3 Paleontology

Extended and Secondary Study Areas – Alternative B

Construction, Operation, and Maintenance Impacts

The impacts associated with Alternative B, as they relate to paleontological resources (**Impact Paleo-1**), would be the same as described for Alternative A for the Extended and Secondary study areas.

Primary Study Area – Alternative B

Construction, Operation, and Maintenance Impacts

Many Project facilities would be the same for Alternatives A and B (see Table 3-1, Chapter 3 Description of the Sites Reservoir Project Alternatives). These facilities would require the same construction methods and operation and maintenance activities regardless of Project alternative, and would, therefore, result in the same construction, operation, and maintenance impacts to paleontological resources. Unless explicitly discussed below, impacts at all Project facilities are anticipated to be the same as previously discussed for Alternative A.

The boundary of the Project Buffer would be the same for Alternatives A and B, but because the footprints of some of the Project facilities that are surrounded by the Project Buffer would differ between the Project alternatives, the acreage of land within the Project Buffer would also differ. However, this difference in the size of the area included within the buffer would not change the type of construction, operation, and maintenance activities that were described for Alternative A. It would, therefore, have the same impact on paleontological resources (**Impact Paleo-1**) as described for Alternative A.

The major differences between Alternatives B and A are related to the increased size of Sites Reservoir with Alternative B. The increase in reservoir size necessitates the addition of two saddle dams and the movement of various project components. In addition, Alternative B replaces the Delevan Pipeline Intake/Discharge Facilities with the Delevan Pipeline Discharge Facility. The Alternative B facilities' construction impacts on paleontological resources that would differ from those described for Alternative A are discussed below.

Sites Reservoir Inundation Area (1.8 MAF)

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

The reservoir included in Alternative B would be larger than for Alternative A, but would affect the same geologic units. These units consist of the low sensitivity Boxer Formation and the low- to moderate-sensitivity Cortina Formation, as well as low sensitivity basin fill. However, the larger reservoir may result in greater effects to paleontological resources than would occur with Alternative A. Construction of the 1.8-MAF Sites Reservoir would, therefore, result in a **potentially significant impact** to paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

Sites Reservoir Dams

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

The larger Sites Reservoir Inundation Area included in Alternative B necessitates slightly different locations for each dam and a larger excavation area for the footprints of Sites and Golden Gate dams, and therefore, may result in greater effects to paleontological resources than would occur with Alternative A. The effects on paleontological resources from construction of Sites and Golden Gate dams under Alternative B would, therefore, result in a **potentially significant impact** to paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

In addition, Alternative B includes nine saddle dams, whereas Alternative A includes seven saddle dams, so more area would be disturbed with Alternative B than with Alternative A. The saddle dams would be located around the rim of Sites Reservoir, and therefore, would affect the low sensitivity Boxer Formation and low sensitivity basin fill, similar to that described for Alternative A. The effects on paleontological resources from construction of the Alternative B saddle dams would, therefore, result in a **potentially significant impact** to paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

Road Relocations and South Bridge

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

Excavations for Alternative B would be slightly less extensive than for Alternative A. The lengths of the saddle dam access roads would be reduced for Alternative B because the dams would be larger and are located closer to the main roads. This would, therefore, reduce the potential impacts to paleontological resources in those areas. However, an extension of an access road would be constructed for Alternative B to provide access from Saddle Dam 3 to Saddle Dams 1 and 2. This road extension would affect the Boxer Formation and overlying low sensitivity basin fill. Effects on paleontological resources from construction associated with road relocations and the South Bridge would be similar for Alternative B to the impacts described for Alternative A and would, therefore, result in a **potentially significant impact** to paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

Sites/Delevan Overhead Power Line

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

The length of the proposed Sites/Delevan Overhead Power Line for Alternative B is greatly reduced from the length associated with Alternative A and would extend only from the Sites Electrical Switchyard to its connection with the existing WAPA or PG&E transmission line. Effects on paleontological resources from construction of the Alternative B overhead power line would, therefore, be greatly reduced, when compared to the Alternative A overhead power line. The Alternative B overhead power line would extend through the westernmost margin of the Sacramento Valley, and would affect the low- to moderate-sensitivity Cortina Formation and low sensitivity basin fill, and would, therefore, result in a **potentially significant impact** to paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

Delevan Pipeline Discharge Facility

Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources

The smaller size of the Delevan Pipeline Discharge Facility, when compared to the Delevan Pipeline Intake/Discharge Facilities that are included in Alternative A, would lessen the effects to high and moderate paleontologically sensitive formations. Impacts to paleontological resources would be similar to those discussed for Alternative A and would, therefore, result in a **potentially significant impact** to paleontological resources, when compared to the Existing Conditions/No Project/No Action Condition.

16.3.6 Impacts Associated with Alternative C

16.3.6.1 Geology and Soils

Extended and Secondary Study Areas – Alternative C

Construction, Operation, and Maintenance Impacts

The impacts associated with Alternative C, as they relate to geology and soils (**Impact Geo/Soils-1**), soil erosion and loss of topsoil (**Impact Geo/Soils-2**), the level of risk to life and property from activities on expansive soil (**Impact Geo/Soils-3**), and soils that are incapable of supporting septic tanks or alternative wastewater disposal systems (**Impact Geo/Soils-4**), would be the same as described for Alternative A for the Extended and Secondary study areas.

Primary Study Area – Alternative C

Construction, Operation, and Maintenance Impacts

Many Project facilities would be the same for Alternatives A and C (see Chapter 3 Description of the Sites Reservoir Project Alternatives, Table 3-1). These facilities would require the same construction methods and operation and maintenance activities regardless of Project alternative, and would, therefore, result in the same construction, operation, and maintenance impacts to geology and soils. Unless explicitly discussed below, impacts at all Project facilities are anticipated to be the same as previously discussed for Alternative A.

The boundary of the Project Buffer would be the same for Alternatives A, B, and C, but because the footprints of some of the Project facilities that are surrounded by the Project Buffer would differ between the Project alternatives, the acreage of land within the Project Buffer would also differ. However, this difference in the size of the area included within the buffer would not change the type of construction, operation, and maintenance activities that were described for Alternative A. It would, therefore, have the same impact on geology and soils (**Impact Geo/Soils-1**), soil erosion and loss of topsoil (**Impact Geo/Soils-2**), the level of risk to life and property from activities on expansive soil (**Impact Geo/Soils-3**), and soils that are incapable of supporting septic tanks or alternative wastewater disposal systems (**Impact Geo/Soils-4**) as described for Alternative A.

The Alternative C design of the Sites/Delevan Overhead Power Line and Delevan Pipeline Intake/Discharge Facilities is the same as described for Alternative A. These facilities would require the same construction methods and operation and maintenance activities regardless of Project alternative, and would, therefore, result in the same construction, operation, and maintenance impacts on geology and soils (**Impact Geo/Soils-1**), soil erosion and loss of topsoil (**Impact Geo/Soils-2**), the level of risk to life and property from activities on expansive soil (**Impact Geo/Soils-3**), and soils that are incapable of supporting septic tanks or alternative wastewater disposal systems (**Impact Geo/Soils-4**) as described for Alternative A.

The Alternative C design of the Sites Reservoir Inundation Area and Dams, Recreation Areas, and Road Relocations and South Bridge is the same as described for Alternative B. These facilities would require the same construction methods and operation and maintenance activities regardless of Project alternative, and would, therefore result in the same construction, operation, and maintenance impacts to geology and soils (**Impact Geo/Soils-1**), soil erosion and loss of topsoil (**Impact Geo/Soils-2**), the level of risk to life and property from activities on expansive soil (**Impact Geo/Soils-3**), and soils that are incapable of supporting septic tanks or alternative wastewater disposal systems (**Impact Geo/Soils-4**) as described for Alternative B.

16.3.6.2 Minerals

Extended and Secondary Study Areas – Alternative C

Construction, Operation, and Maintenance Impacts

The impacts associated with Alternative C, as they relate to known mineral resources of value (**Impact Min-1**), locally important resources (**Impact Min-2**), and naturally occurring asbestos (**Impact Min-3**), would be the same as described for Alternative A for the Extended and Secondary study areas.

Primary Study Area – Alternative C

Construction, Operation, and Maintenance Impacts

Many Project facilities would be the same for Alternatives A, B, and C (see Chapter 3 Description of the Sites Reservoir Project Alternatives, Table 3-1). These facilities would require the same construction methods and operation and maintenance activities regardless of Project alternative, and would, therefore, result in the same construction, operation, and maintenance impacts to minerals. Unless explicitly discussed below, impacts at all Project facilities are anticipated to be the same as previously discussed for Alternative A).

The boundary of the Project Buffer would be the same for Alternatives A, B, and C, but because the footprints of some of the Project facilities that are surrounded by the Project Buffer would differ between the Project alternatives, the acreage of land within the Project Buffer would also differ. However, this difference in the size of the area included within the buffer would not change the type of construction, operation, and maintenance activities that were described for Alternative A. It would, therefore, have the same impact on known mineral resources of value (**Impact Min-1**), locally important resources (**Impact Min-2**), and naturally occurring asbestos (**Impact Min-3**) as described for Alternative A.

The Alternative C design of the Sites/Delevan Overhead Power Line and Delevan Pipeline Intake/Discharge Facilities is the same as described for Alternative A. These facilities would require the same construction methods and operation and maintenance activities regardless of Project alternative, and would, therefore, result in the same construction, operation, and maintenance impacts to known mineral resources of value (**Impact Min-1**), locally important resources (**Impact Min-2**), and naturally occurring asbestos (**Impact Min-3**) as described for Alternative A.

The Alternative C design of the Sites Reservoir Inundation Area and Dams, Recreation Areas, and Road Relocations and South Bridge is the same as described for Alternative B. These facilities would require the same construction methods and operation and maintenance activities regardless of Project alternative, and would, therefore result in the same construction, operation, and maintenance impacts to known mineral resources of value (**Impact Min-1**), locally important resources (**Impact Min-2**), and naturally occurring asbestos (**Impact Min-3**) as described for Alternative B.

16.3.6.3 Paleontology

Extended and Secondary Study Areas – Alternative C

Construction, Operation, and Maintenance Impacts

The impacts associated with Alternative C, as they relate to paleontological resources (**Impact Paleo-1**), would be the same as described for Alternative A for the Extended and Secondary study areas.

Primary Study Area – Alternative C

Construction, Operation, and Maintenance Impacts

Many Project facilities would be the same for Alternatives A, B, and C (see Chapter 3 Description of the Sites Reservoir Project Alternatives, Table 3-1). These facilities would require the same construction methods and operation and maintenance activities regardless of Project alternative, and would, therefore, result in the same construction, operation, and maintenance impacts to paleontological resources. Unless explicitly discussed below, impacts at all Project facilities are anticipated to be the same as previously discussed for Alternative A).

The boundary of the Project Buffer would be the same for Alternatives A, B, and C, but because the footprints of some of the Project facilities that are surrounded by the Project Buffer would differ between the Project alternatives, the acreage of land within the Project Buffer would also differ. However, this difference in the size of the area included within the buffer would not change the type of construction, operation, and maintenance activities that were described for Alternative A. It would, therefore, have the same impact on paleontological resources (**Impact Paleo-1**) as described for Alternative A.

The Alternative C design of the Sites/Delevan Overhead Power Line and Delevan Pipeline Intake/Discharge Facilities is the same as described for Alternative A. These facilities would require the same construction methods and operation and maintenance activities regardless of Project alternative, and would, therefore, result in the same construction, operation, and maintenance impacts to paleontological resources (**Impact Paleo-1**) as described for Alternative A.

The Alternative C design of the Sites Reservoir Inundation Area and Dams, Recreation Areas, and Road Relocations and South Bridge is the same as described for Alternative B. These facilities would require the same construction methods and operation and maintenance activities regardless of Project alternative, and would, therefore result in the same construction, operation, and maintenance impacts to paleontological resources (**Impact Paleo-1**) as described for Alternative B.

16.3.7 Impacts Associated with Alternative D

16.3.7.1 Geology and Soils

Extended and Secondary Study Areas – Alternative D

Construction, Operation, and Maintenance Impacts

The impacts associated with Alternative D, as they relate to geology and soils (**Impact Geo/Soils-1**), soil erosion and loss of topsoil (**Impact Geo/Soils-2**), the level of risk to life and property from activities on expansive soil (**Impact Geo/Soils-3**), and soils that are incapable of supporting septic tanks or alternative wastewater disposal systems (**Impact Geo/Soils-4**), would be the same as Alternative A for the Extended and Secondary study areas.

Primary Study Area – Alternative D

Construction, Operation, and Maintenance Impacts

Most Project facilities would be the same for Alternatives A, B, C, and D (see Chapter 3 Description of the Sites Reservoir Project Alternatives, Table 3-1). These facilities would require the same construction methods and operation and maintenance activities regardless of Project alternative, and would, therefore, result in the same construction, operation, and maintenance impacts to geology and soils.

The boundary of the Project Buffer would be the same for Alternatives A, B, C, and D, but because the footprints of some of the Project facilities that are surrounded by the Project Buffer would differ between the Project alternatives, the acreage of land within the Project Buffer would also differ. However, this difference in the size of the area included within the buffer would not change the type of construction, operation, and maintenance activities that were described for Alternative C. It would, therefore, have the same impact on geology and soils (**Impact Geo/Soils-1**), soil erosion and loss of topsoil (**Impact Geo/Soils-2**), the level of risk to life and property from activities on expansive soil (**Impact Geo/Soils-3**), and soils that are incapable of supporting septic tanks or alternative wastewater disposal systems (**Impact Geo/Soils-4**) as Alternative A.

The Alternative D design of the Delevan Overhead Power Line (north-south alignment) would require the same construction methods and operation and maintenance activities as described for the overhead power line alignment for Alternatives A, B, and C (west-east alignment along the Delevan Pipeline). The Alternative D alignment would result in similar construction, operation, and maintenance impacts as Alternative A on geology and soils (**Impact Geo/Soils-1**), soil erosion and loss of topsoil (**Impact Geo/Soils-2**), and soils that are incapable of supporting septic tanks or alternative wastewater disposal systems (**Impact Geo/Soils-4**).

The Delevan Overhead Power Line for Alternative D, however, would affect a larger area than the alignment for the other alternatives because the overhead power line for Alternative D does not follow along a proposed pipeline construction zone. The soil and geology in the Alternative D alignment are very similar, however, to the west-east alignment, consisting of fine-grained alluvial soil deposits. Impacts related to the level of risk to life and property from activities on expansive soil (**Impact Geo/Soils-3**) would be **less than significant** because the soils along the Alternative D alignment have a low expansion potential.

The Alternative D design of the Delevan Pipeline Intake/Discharge Facilities would be the same as described for Alternative A. These facilities would require the same construction methods and operation and maintenance activities regardless of Project alternative, and would, therefore, result in the same construction, operation, and maintenance impacts on geology and soils (**Impact Geo/Soils-1**), soil erosion and loss of topsoil (**Impact Geo/Soils-2**), the level of risk to life and property from activities on expansive soil (**Impact Geo/Soils-3**), and soils that are incapable of supporting septic tanks or alternative wastewater disposal systems (**Impact Geo/Soils-4**) as Alternative A.

The Alternative D design of the Sites Reservoir Inundation Area and Dams is the same as Alternative A. While Alternative D Recreation Areas and South Bridge and Roads are different, the impacts related to geology and soils would be similar. These facilities would require the same construction methods and operation and maintenance activities regardless of Project alternative, and would, therefore result in the same construction, operation, and maintenance impacts to geology and soils (**Impact Geo/Soils-1**), soil erosion and loss of topsoil (**Impact Geo/Soils-2**), the level of risk to life and property from activities on expansive soil (**Impact Geo/Soils-3**), and soils that are incapable of supporting septic tanks or alternative wastewater disposal systems (**Impact Geo/Soils-4**) as Alternative A.

16.3.7.2 Minerals

Extended and Secondary Study Areas – Alternative D

Construction, Operation, and Maintenance Impacts

The impacts associated with Alternative D, as they relate to known mineral resources of value (**Impact Min-1**), locally important resources (**Impact Min-2**), and naturally occurring asbestos (**Impact Min-3**), would be the same as Alternative A for the Extended and Secondary study areas.

Primary Study Area – Alternative D

Construction, Operation, and Maintenance Impacts

Many Project facilities would be the same for Alternatives A, B, C, and D (see Chapter 3 Description of the Sites Reservoir Project Alternatives, Table 3-1). These facilities would require the same construction methods and operation and maintenance activities regardless of Project alternative, and would, therefore, result in the same construction, operation, and maintenance impacts to minerals.

The boundary of the Project Buffer would be the same for Alternatives A, B, C, and D, but because the footprints of some of the Project facilities that are surrounded by the Project Buffer would differ between the Project alternatives, the acreage of land within the Project Buffer would also differ. However, this difference in the size of the area included within the buffer would not change the type of construction, operation, and maintenance activities that were described for Alternative C. It would, therefore, have the same impact on known mineral resources of value (**Impact Min-1**), locally important resources (**Impact Min-2**), and naturally occurring asbestos (**Impact Min-3**) as Alternative A.

The Alternative D design of the Sites/Delevan Overhead Power Line would follow a different alignment from the other Project alternatives as described in Chapter 3 Description of the Sites Reservoir Project Alternatives, but would require the same construction methods and operation and maintenance activities as Alternatives A, B, and C. The Alternative D alignment would result in the same construction, operation, and maintenance impacts to known mineral resources of value (**Impact Min-1**), locally important resources (**Impact Min-2**), and naturally occurring asbestos (**Impact Min-3**) as for Alternative A.

The Alternative D design of the Delevan Pipeline Intake/Discharge Facilities is the same as described for Alternative C. These facilities would require the same construction methods and operation and maintenance activities regardless of alternative, and would, therefore, result in the same construction, operation, and maintenance impacts to known mineral resources of value (**Impact Min-1**), locally important resources (**Impact Min-2**), and naturally occurring asbestos (**Impact Min-3**) as for Alternative A.

The Alternative D design of the Sites Reservoir Inundation Area and Dams would be the same as described for Alternative C. While the Alternative D design of the Recreation Areas and South Bridge and Roads are different, the impacts related to minerals would be the same as described for Alternative A. These facilities would require the same construction methods and operation and maintenance activities regardless of alternative, and would, therefore result in the same construction, operation, and maintenance impacts to known mineral resources of value (**Impact Min-1**), locally important resources (**Impact Min-2**), and naturally occurring asbestos (**Impact Min-3**) as Alternative A.

16.3.7.3 Paleontology

Extended and Secondary Study Areas – Alternative D

Construction, Operation, and Maintenance Impacts

The impacts associated with Alternative D, as they relate to paleontological resources (**Impact Paleo-1**), would be the same as Alternative A for the Extended and Secondary study areas.

Primary Study Area – Alternative D

Construction, Operation, and Maintenance Impacts

Many Project facilities would be the same for Alternatives A, B, C, and D (see Chapter 3 Description of the Sites Reservoir Project Alternatives, Table 3-1). These facilities would require the same construction methods and operation and maintenance activities regardless of Project alternative, and would, therefore, result in the same construction, operation, and maintenance impacts to paleontological resources. Therefore, those facilities are not discussed further.

The boundary of the Project Buffer would be the same for Alternatives A, B, C, and D, but because the footprints of some of the Project facilities that are surrounded by the Project Buffer would differ between the Project alternatives, the acreage of land within the Project Buffer would also differ. However, this difference in the size of the area included within the buffer would not change the type of construction, operation, and maintenance activities that were described for Alternative A. It would, therefore, have the same impact on paleontological resources (**Impact Paleo-1**) as Alternative A. With the exception of dredging and demolition activities, all construction-related excavations included in Alternative D have the potential to result in **potentially significant impacts to** paleontological resources.

As described in Chapter 3 Description of the Sites Reservoir Project Alternatives, the Alternative D design of the Sites/Delevan Overhead Power Line would differ from the other Project alternatives. The overhead power line would be located next to SR 45 between Colusa and the Delevan Pumping/Generating Plant in a north-south alignment. Despite the change in location, paleontological resources in the area are the same as described for the previous alternatives. Additionally, the facilities would require the same construction methods and operation and maintenance activities regardless of Project alternative, and would, therefore, result in the same construction, operation, and maintenance impacts to paleontological resources (**Impact Paleo-1**) as Alternative A.

The Alternative D design of the Delevan Pipeline Intake/Discharge Facilities is the same as Alternative A. These facilities would require the same construction methods and operation and maintenance activities regardless of Project alternative, and would, therefore, result in the same construction, operation, and maintenance impacts to paleontological resources (**Impact Paleo-1**) as Alternative A.

The Alternative D design of the Sites Reservoir Inundation Area and Dams would be the same as described for Alternative B. While the Alternative D design of the Recreation Areas and South Bridge and Roads is slightly different than the other Project alternatives, impacts related to paleontology are the same as Alternative C. These facilities would require the same construction methods and operation and maintenance activities regardless of Project alternative, and would, therefore result in the same construction, operation, and maintenance impacts to paleontological resources (**Impact Paleo-1**) as Alternative B.

16.4 Mitigation Measures

Mitigation measures are provided below and summarized in Table 16-9 for the impacts that have been identified as potentially significant.

Table 16-9
Summary of Mitigation Measures for
Sites Reservoir Project Impacts to Paleontological Resources

Impact	Associated Project Facility	LOS Before Mitigation	Mitigation Measure	LOS After Mitigation
Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources	All Project Facilities, with the exception of the Project Buffer	Potentially Significant	Mitigation Measure Paleo-1a: Retain a Qualified Paleontological Resource Specialist Prior to the Start of Construction Mitigation Measure Paleo-1b: Consultation with the Paleontological Resource Specialist Prior to and during Project Construction Mitigation Measure Paleo-1c: Prepare and Implement a Paleontological Resources Monitoring and Mitigation Plan Mitigation Paleo-1d: Conduct Paleontological Resources Awareness Training Mitigation Measure Paleo-1e: Conduct Monitoring during Project Construction and Prepare Monthly Reports Mitigation Measure Paleo-1f: Ensure Implementation of the Paleontological Resources Monitoring and Mitigation Plan	Potentially Significant and Unavoidable

Note:
LOS = Level of Significance

16.4.1 Geology and Soils

Because no potentially significant impacts were identified, no mitigation is required or recommended.

16.4.2 Minerals

Because no potentially significant impacts were identified, no mitigation is required or recommended.

16.4.3 Paleontology

The significance of paleontological resources originates chiefly in their scientific value. Therefore, mitigation of impacts to paleontological resources can be achieved by the recovery of that value. This is accomplished through paleontological resources monitoring, and the scientific recovery of discovered fossils when they are encountered. Through the controlled excavation, study, and appropriate museum curation of fossil materials their scientific value is preserved, and potentially even enhanced through the new knowledge developed during their initial study. These mitigation measures are consistent with those recommended by SVP (2010). While mitigation would provide scientific value through preservation and curation, removal of the resources could result in a potentially significant and unavoidable impact.

Mitigation Measure Paleo-1a: Retain a Qualified Paleontological Resource Specialist Prior to the Start of Construction

The Authority and Reclamation shall retain a qualified Paleontological Resource Specialist at least 90 days prior to the start of construction. The Authority and Reclamation shall keep resumes on file for the Paleontological Resource Specialist as well as qualified Paleontological Resource Monitors working on the Project. The Paleontological Resource Specialist shall meet the minimum or equivalent qualifications for a paleontological resources manager, as described in the SVP guidelines (2010). The experience of the Paleontological Resource Specialist shall include the following:

- Ability to recognize and collect fossils in the field
- Geological and biostratigraphic expertise
- Proficiency in identifying vertebrate and invertebrate fossils, and in assessing their scientific significance
- At least 3 years of paleontological resource mitigation and field experience in California and at least 1 year of experience leading paleontological resource mitigation and field activities

The Authority and Reclamation shall require that the Paleontological Resource Specialist obtains qualified paleontological resource monitors to monitor Project construction activities, as the Paleontological Resource Specialist determines necessary on the Project. Paleontological Resource Monitors shall have the equivalent of the following qualifications:

- BS or BA degree in geology or paleontology and 1 year of experience monitoring in California
- AS or AA in geology, paleontology, or biology and 4 years' experience monitoring in California
- Enrollment in upper division classes pursuing a degree in the fields of geology or paleontology and 2 years of monitoring experience in California

Mitigation Measure Paleo-1b: Consultation with the Paleontological Resource Specialist Prior to and during Project Construction

At least 30 days prior to the start of Project construction, the Authority and Reclamation shall provide maps or drawings to the Paleontological Resource Specialist that show the planned construction footprint. Maps shall identify all areas of the Project where ground disturbance is anticipated. (Site grading plan and plan and profile drawings for the utility lines are appropriate for this purpose). The plan drawings shall show the location, depth, and extent of all ground disturbances affecting paleontologically sensitive sediment. If Project construction proceeds in phases, maps and drawings may be submitted prior to the start of each phase. In addition, the proposed schedule of each Project phase shall be provided to the Paleontological Resource Specialist. Before work commences on affected phases, the Authority and Reclamation shall notify the Paleontological Resource Specialist of any construction phase scheduling changes. If paleontological resources monitoring is ongoing, the Authority and Reclamation shall ensure that the Paleontological Resource Specialist or Paleontological Resource Monitor consults weekly with the

Project superintendent or construction field manager to confirm area(s) to be worked the following week and until ground disturbance is completed.

Mitigation Measure Paleo-1c: Prepare and Implement a Paleontological Resources Monitoring and Mitigation Plan

The Authority and Reclamation shall ensure that the Paleontological Resource Specialist prepares a Paleontological Resources Monitoring and Mitigation Plan (PRMMP) to identify general and specific measures to minimize potential impacts to significant paleontological resources. Approval of the PRMMP by the Authority and Reclamation shall occur prior to any ground disturbance. The PRMMP shall function as the formal guide for paleontological resources monitoring, collecting, and sampling activities, and may be modified by the Paleontological Resource Specialist to accommodate new data or Project changes. This document shall be used as the basis of discussion when on-site decisions or changes are proposed. Copies of the PRMMP shall reside with the Paleontological Resource Specialist, each monitor, the Authority's and Reclamation's on-site manager, and the Authority and Reclamation.

The PRMMP shall be developed in accordance with professional guidelines, and be consistent with those issued by SVP (2010) and shall include the following:

Procedures for the performance and sequence of resource-related tasks, such as any literature searches, preconstruction surveys, appropriate worker environmental training module, construction monitoring, mapping and data recovery, discovery situations, fossil preparation and collection, identification and inventory, preparation of final reports, transmittal of materials for curation, and final report shall be provided in the PRMMP, including:

- A discussion of the geologic units expected to be encountered, the location and depth of the units relative to the Project, when known, and the known paleontological sensitivity of those units
- A discussion of the locations of where the monitoring of Project construction activities is deemed necessary, and a proposed plan for monitoring and sampling
- An explanation of why, how, and how much sampling is expected to take place and in what units, including descriptions of different sampling procedures that may be used
- A discussion of procedures to be followed in the event of a significant fossil discovery, diverting construction away from a find, resuming construction, and how notifications shall be performed
- A discussion of equipment and supplies necessary for collection of fossil materials and any specialized equipment needed to prepare, remove, load, transport, and analyze large-sized fossils or extensive fossil deposits
- Procedures for inventory, preparation, and delivery for curation into a retrievable storage collection in a public repository or museum, which meet SVP standards and requirements for the curation of paleontological resources
- Identification of the institution(s) that shall be approached to receive data and fossil materials collected, and requirements or specifications for materials delivered for curation

The PRMMP shall also provide guidance for preparation of a Paleontological Resources Report by the designated Paleontological Resource Specialist at the conclusion of ground-disturbing activities that may affect paleontological resources. The Paleontological Resources Report shall include an analysis of the collected fossil materials and related information, including a description and inventory of recovered fossil materials, a map showing the location of paleontological resources encountered, determinations of sensitivity and significance, and a statement by the Paleontological Resource Specialist that Project impacts to paleontological resources have been mitigated below the LOS.

Mitigation Measure Paleo-1d: Conduct Paleontological Resources Awareness Training

Prior to ground disturbance and for the duration of Project construction activities involving ground disturbance, the Paleontological Resource Specialist shall prepare, and the Authority and Reclamation shall conduct, weekly paleontological resources awareness training for the following workers: project managers, construction supervisors, forepersons, and general workers involved with or who operate ground-disturbing equipment or tools. Workers shall not excavate in paleontologically sensitive sediments prior to receiving paleontological resources awareness training. Worker training shall consist of a video or in-person presentation. The paleontological resources awareness training module may be combined with other training modules prepared for cultural and biological resources, hazardous materials, or other areas of interest or concern.

The paleontological resources awareness training shall address the possibility of encountering paleontological resources in the field, the sensitivity and importance of these resources, and legal obligations to preserve and protect those resources. The training shall include:

- A discussion of applicable laws and penalties under the law
- Good quality photographs or physical examples of vertebrate fossils
- Information that the Paleontological Resource Specialist or Paleontological Resource Monitor has the authority to halt or redirect construction in the vicinity of a fossil discovery or unanticipated impact to a paleontological resource
- Instruction that employees are to halt or redirect work in the vicinity of a find and to contact their supervisor and the Paleontological Resource Specialist or Paleontological Resource Monitor
- An informational brochure that identifies reporting procedures in the event of a discovery
- A certification of completion form signed by each worker indicating that he/she has received the training

Mitigation Measure Paleo-1e: Conduct Monitoring during Project Construction and Prepare Monthly Reports

The Authority and Reclamation shall ensure that the Paleontological Resource Specialist and Paleontological Resource Monitor(s) monitor construction excavations consistent with the PRMMP in areas where potential fossil-bearing materials have been identified, both at reservoir sites and along any constructed linear facilities associated with the Project. In the event that the Paleontological Resource Specialist determines full-time monitoring is not necessary in locations that were identified as potentially fossil-bearing in the PRMMP, the Paleontological Resource Specialist shall notify the Authority and Reclamation.

The Authority and Reclamation shall ensure that the Paleontological Resource Specialist and Paleontological Resource Monitor(s) have the authority to halt or redirect construction if paleontological resources are encountered. The Authority and Reclamation shall ensure that there is no interference with monitoring activities, as directed by the Paleontological Resource Specialist.

The Authority and Reclamation shall ensure that the Paleontological Resource Specialist prepares and submits monthly summaries of monitoring and other paleontological resources management activities. The summary shall include the name(s) of the Paleontological Resource Specialist or Paleontological Resource Monitor(s) active during the month, general descriptions of training and monitored construction activities; and general locations of excavations, grading, and other activities. A section of the report shall include the geologic units or subunits encountered, descriptions of samplings, if any, and a list of identified fossils. A final section of the report shall address any issues or concerns about the Project relating to paleontological resources mitigation activities, including any incidents of non-compliance or any changes to the monitoring plan by the Paleontological Resource Specialist. If no monitoring took place during the month, the report shall include an explanation as to why monitoring was not conducted.

Mitigation Measure Paleo-1f: Ensure Implementation of the Paleontological Resources Monitoring and Mitigation Plan

The Authority and Reclamation, through the designated Paleontological Resource Specialist, shall ensure that all components of the PRMMP are adequately performed during construction.

Although implementation of **Mitigation Measures Paleo-1a, Paleo-1b, Paleo-1c, Paleo-1d, Paleo-1e**, and **Paleo-1f** would reduce impacts related to paleontological resources and potentially provide scientific value through preservation and curation, removal of the resources could result in a **potentially significant and unavoidable impact.** For example, if a resource is destroyed by Project construction.