4.4 Geology, Soils, and Seismicity

This section presents an analysis of potential geology, soils, and seismicity impacts that would result from implementation of the Los Vaqueros Reservoir Expansion Project. The section includes a description of the affected environment, the associated regulatory framework (including all applicable geology, soils, and seismicity policies), the methodology, and the impact assessment. Mitigation measures are identified, where necessary, to avoid or reduce potential impacts.

4.4.1 Affected Environment

Regulatory Setting

The following federal, state, and local regulations relevant to geology, soils, and seismicity are applicable to the proposed project.

Federal

The Dam Safety and Security Act of 2002 (Public Law 107-310)

The Dam Safety and Security Act of 2002 amends the National Dam Safety Program Act of 1996 (Public Law 104-303, Section 215), which amends the National Dam Inspection Act of 1972 (Public Law 92-367). The purpose of these acts is to reduce the risks to life and property from dam failure in the United States through the establishment and maintenance of a national dam safety program that integrates the expertise and resources of the federal and non-federal communities to achieve national dam safety hazard reduction. The acts established:

- A national dam inventory
- A national inspection program by the U.S. Army Corps of Engineers with reports to the appropriate state and federal agencies
- The Federal Interagency Committee on Dam Safety chaired by the Director of the Federal Emergency Management Agency (FEMA)
- A dam safety training program
- Assistance for state dam safety programs

State

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act (formerly the Alquist-Priolo Special Studies Zone Act), signed into law in December 1972, requires the delineation of fault rupture zones along active faults in California. The purpose of the Alquist-Priolo Act is to regulate development on or near active fault traces to reduce the hazard of fault rupture and to prohibit the location of most structures
for human occupancy across these traces. Cities and counties must regulate certain development projects within the zones, which includes withholding permits until geologic investigations demonstrate that development sites are not threatened by future surface displacement (Hart, 1997). Surface fault rupture is not necessarily restricted to the area within an Alquist-Priolo zone. None of the project components are located in an Alquist-Priolo fault rupture zone.

**Seismic Hazards Mapping Act**

The Seismic Hazards Mapping Act was developed to protect the public from the effects of strong ground shaking, liquefaction, landslides, or other ground failure, and from other hazards caused by earthquakes. This act requires the State Geologist to delineate various seismic hazard zones and requires cities, counties, and other local permitting agencies to regulate certain development projects within these zones. Before a development permit is granted for a site within a seismic hazard zone, a geotechnical investigation of the site has to be conducted and appropriate mitigation measures incorporated into the project design. Mapping within the study area has not been completed by the California Geological Survey at the time of preparation of this document although it is in progress for the Altamont quadrangle, which would include a portion of the Transfer-Bethany Pipeline. However, to date there are no elements of the proposed project that have been identified in a Seismic Hazards zone.

**California Department of Water Resources, Division of Safety of Dams**

Division 3 of the California Water Code—the statute governing dam safety in California—places responsibility for the safety of non-federal dams and reservoirs under the jurisdiction of the California Department of Water Resources (DWR) Division of Safety of Dams (DSOD). DSOD regulates the construction of all non-federal dams in California that are 25 feet or more in height or have an impounding capacity of 50 acre-feet or more. DSOD’s engineers and engineering geologists provide multiple critical reviews of new dams as well as for the enlargement and alteration of existing dams. DSOD reviews detailed studies prepared by the dam owner that address all aspects of the design such as the site geology, seismic setting, site geotechnical investigations, laboratory testing, proposed construction materials, seismic analyses, and design of the dam. Construction can only commence once DSOD has provided written approval of the plans and specifications. They then make continuous or periodic inspections during construction to verify conformance with the approved construction documents, and inspect foundations before material is placed.

Before water can be impounded behind a new dam, DWR must issue a certificate of approval to operate. These certificates may contain restrictive conditions and may be amended or revoked. DSOD engineers inspect existing dams on a yearly schedule to verify they are performing safely and are being adequately maintained.

---

1 A “structure for human occupancy” is defined by the Alquist-Priolo Act as any structure used or intended to support or shelter any use or occupancy that has an occupancy rate of more than 2,000 person-hours per year.
California Building Code

The California Building Code (CBC) is another name for the body of regulations known as the California Code of Regulations, Title 24, Part 2. Title 24 is assigned to the California Building Standards Commission which, by law, is responsible for administering, adopting, approving, publishing, and implementing all building standards in California.

Published by the International Code Council, the International Building Code (IBC) is a widely adopted national model building code in the United States. The 2007 CBC incorporates the IBC by reference and includes necessary California amendments. These amendments include criteria for seismic design, and approximately one-third of the CBC has been tailored to California earthquake conditions. The CBC provides engineering design criteria for grading, foundations, retaining walls, and structures within zones of seismic activity. Under the CBC, facilities are assigned seismic design categories (A through F) which are based on spectral response accelerations, soil classifications and properties, and occupancy categories. The higher the seismic design category, the more stringent the design criteria are required.

CCWD water system projects are not processed like development projects through a local county or city building department for compliance with the CBC. However, CCWD incorporates the IBC and CBC building code requirements in design and construction of all of its projects.

Local

Contra Costa County General Plan

The Contra Costa County General Plan includes goals, policies, and measures related to geology, soils, and seismicity. Goals and policies that potentially apply to the proposed project include the establishment and enforcement of erosion control procedures for all construction and grading projects (8-63); implementation of a soil conservation program which would reduce soil erosion for projects which would increase waterway or hillside erosion (8-cf); reduction of injuries and health risks resulting from the effects of earthquake ground shaking on structures, facilities, and utilities (10-B); modification of the location and/or design of proposed facilities or buildings in areas near active or inactive earthquake faults (10-13); and the requirement of a comprehensive geologic and engineering study for any critical structure (10-c) (Contra Costa County, 2005). A detailed list of the goals and policies relevant to geology, soils, and seismicity is located in Appendix E-2.

Alameda County – East County Area Plan

The East County Area Plan also contains goals, policies, and implementation programs related to geology, soils, and seismicity. These policies include evaluating the degree to which development could result in the loss of lives or property in the event of a natural disaster (310); ensuring that new major public facilities (i.e., hospitals, water storage, communications facilities) are sited in areas of low geologic risk (311); ensuring that new major transportation facilities and pipelines are designed to avoid or minimize crossings of active fault traces (312); and requiring that buildings be designed and constructed to withstand ground shaking (315). Specific policies are listed in Appendix E-1.
CCWD Standards

CCWD has specified seismic standards for all CCWD facilities in its Engineering Standard Practice Number 023.0-98 for Seismic Design Requirements and its Engineering Standard Practices and Specifications. These documents serve as a guideline for the design, repair, alteration, and rehabilitation of low-rise buildings, water retention structures, canals, small buried structures, underground piping, atmospheric storage tanks, and silos and pressure vessels. These standards incorporate codes and specifications published by the International Conference of Building Officials, the American Concrete Institute, the American Institute of Steel Construction, and the American Water Works Association. The IBC, published by the International Code Council, is a widely adopted national model building code in the United States and is used by CCWD as a basis for its building standards. Because the seismic environment in the CCWD area is more severe than the conditions anticipated by these publications, standards are modified accordingly. The purpose of CCWD standards is to provide greater reliability for CCWD facilities than would be obtained only by application of the IBC standards.

Environmental Setting

Regional Setting

The Los Vaqueros Reservoir Expansion Project facilities generally would be located in the Coast Ranges geomorphic province of California, although some of the easternmost components of the project extend into the Great Valley geomorphic province (California Geological Survey, 2002). The Coast Ranges province lies between the Pacific Ocean and the Great Valley (Sacramento and San Joaquin Valleys) provinces and stretches from the Oregon border to the Santa Ynez Mountains near Santa Barbara. Much of the Coast Ranges province is composed of marine sedimentary deposits and volcanic rocks that form northwest-trending mountain ridges and valleys, running subparallel to the San Andreas Fault Zone. The geology in this part of the Coast Ranges reflects a long history of mountain building, weathering, erosion, and sediment deposition in terrestrial, shallow marine, and deeper ocean environments. These processes have been driven by the interaction of the Pacific and North American Plates, which created several active faults, including the San Andreas, Hayward, and Greenville. The Great Valley geomorphic province—a low-gradient alluvial plain that is up to 50 miles wide and 400 miles long—dominates central California. The province is divided into the northern half, which is drained by the Sacramento River, and the southern half, which is drained by the San Joaquin River.

Local Setting

The project area is located in eastern Contra Costa County and a portion of northeastern Alameda County, southeast of Mount Diablo. The topography of the Los Vaqueros Dam site and adjacent area is dominated by northwest-southeast-trending ridge lines that reach an elevation of approximately 1,200 to 1,400 feet in the vicinity of the dam and reservoir. The elevations of intervening valley bottoms are approximately 400 feet mean sea level (msl) in the vicinity of the dam and reservoir. The same topography extends to the southeast towards Bethany Reservoir in Alameda County. In the vicinity of Los Vaqueros Reservoir, these ridges are separated by valleys of varying width; the ridges decline in elevation to the east and become relatively flat as the San Joaquin Valley is approached.
Los Vaqueros Reservoir – Dam Monitoring and Management

The performance and safety of the existing dam are continuously monitored and recorded by an extensive array of instruments that measure internal water pressures within and seepage from the dam and foundation, settlement of the dam, and earthquake-induced accelerations and deformations. The instruments include foundation and embankment piezometers, internal and surface settlement and movement sensors, a seepage measurement weir and a series of strong motion accelerographs. Many of these instruments are read in real time by a data acquisition system that will automatically send a signal to CCWD’s operations center if a preset threshold limit is exceeded. The dam is visually inspected on a regular basis by CCWD staff, and an annual surveillance and monitoring report is prepared and submitted to DSOD.

Geology

Los Vaqueros Reservoir is located in the northwest-trending Diablo Ranges of the Coast Ranges geomorphic province, while several of the proposed project facilities would be located in the flat San Joaquin Valley section of the adjacent Great Valley geomorphic province. The Coast Ranges geomorphic province in the study area is composed of bedded and folded sedimentary rocks. The rocks are of two general ages. The older group is 65- to 144 million-year-old (Cretaceous age) marine sedimentary rocks, while the younger group is 45- to 65-million-year-old (Tertiary age) marine and nonmarine sedimentary rocks.

In the vicinity of the dam site abutments, the bedrock is mapped as the Cretaceous Panoche Formation (Wagner et al., 1990; Simpson and Schmoll, 2001). In the vicinity of the dam site, the Panoche Formation is interbedded sandstone and claystone (URS and MWH, 2004). The beds in this area dip between 15 and 40 degrees (Simpson and Schmoll, 2001; URS and MWH, 2004).

The reservoir is underlain by marine shale bedrock (Wagner et al., 1990). The Panoche Formation interbedded sandstone and claystone extends to the southeast beyond Bethany Reservoir and generally dips to the northeast. To the east of the reservoir, the bedrock in the ridges and valleys is composed of a series of sedimentary rock formations (sandstone, siltstone, claystone) of varying thicknesses. These sedimentary layers dip to the northeast. Their more erosion-resistant sandstone beds tend to form the area’s topographic ridges, while more erodible siltstones or claystones dominate in the valleys. One formation, Domengine marine sandstone, is notable because rock from this formation has been used as fill around road culverts; this rock has proven to be corrosive and requires replacement (ESA et al., 2005).

Kellogg Creek is incised into adjacent river terraces composed of alluvial sediments. To the east and southeast of the reservoir, some of the northwest-southeast-trending valleys have alluvium deposited on their valley floor.

The pipelines extending from the Los Vaqueros Dam toward the Transfer Facility would be located within the Panoche Formation heading eastward until the lower elevations where it transitions into the alluvial sediments as mentioned above. The Transfer Facility is located in an area of tilted sandstone formations that include the Domengine, Markley, and Meganos Formation’s (Wagner, 1990). The Transfer-Bethany pipeline alignment continues within the Panoche Formation.
Landslides

Ground failure can be dependent on slope angle and geology as well as the amount of rainfall, excavation, or seismic activities. A slope failure is a mass of rock, soil, and debris displaced downslope by sliding, flowing, or falling. Steep slopes and downslope creep of surface materials characterize landslide-susceptible areas. Debris flows consist of a loose mass of rocks and other granular material that, if present on a steep slope and saturated, can move downslope.

The rate of rock and soil movements can vary from a slow creep over many years to sudden mass movements.

Construction of the existing Los Vaqueros Dam required the excavation of one landslide down to stable bedrock (Simpson and Schmoll, 2001). URS and MWH (2004) identified landslides in the vicinity of the Los Vaqueros Dam site. They mapped one large landslide and two smaller landslides in the vicinity of the left abutment, and identified three possible landslides upstream of the right abutment of the dam. Several areas of landslides are mapped within the Los Vaqueros Reservoir watershed and along the routes for the Transfer-Bethany Pipeline (Ellen et al., 1997; Pike, 1997). The latter mapping identified slides and earthflows along the upland areas of the pipeline alignment toward the South Bay Aqueduct connection. Slides are larger features that move slowly, in contrast to earthflows, which are smaller but move rapidly. The Transfer Facility is located at lower elevations where the topography is generally gentler and less susceptible to landslides or slope failures. Other facilities located in the flatter regions of the study area include the new Delta Intake and Pump Station, the Delta-Transfer Pipeline, and the Western Area Power Administration (Western) substation. There are no known landslides in these areas and any improvements would not likely cause any slope instability based on the topography.

Seismicity

The study area is in a seismically active region influenced by the faults of the San Andreas system including San Andreas, Hayward, and Calaveras Faults (see Figure 4.4-1). Seismic hazard evaluations for the existing Los Vaqueros Reservoir identified five faults as the most significant seismic sources to the site: the Mount Diablo thrust, Greenville, Calaveras, Hayward, and San Andreas faults (Table 4.4-1; CCWD and Reclamation, 1993). However, for seismic design purposes, the Greenville Fault and the San Andreas Fault were considered as the controlling faults or, in other words, the two faults capable of causing the most damaging effects at the dam. Controlling faults are determined based on the magnitude of the maximum credible earthquake (MCE) that can be generated by a particular fault and the distance between that fault and the proposed improvement. The Greenville Fault is approximately 4 miles from the reservoir and has a calculated MCE of magnitude $M_2^2 7.0$ (URS and MWH, 2004). The MCE on the San Andreas Fault

---

$^2$ Earthquake magnitude is a measure that relates to the seismic energy radiated by an earthquake and measured on a seismograph; it can be reported in slightly different ways (California Geological Survey, 2002b). Moment magnitude, $M$, is the most commonly used scale today because it is considered to give a consistent scale of earthquake size. Moment magnitude is also used in the International Building Code to indicate earthquake size.
Figure 4.4-1
Regional Fault Map

SOURCE: URS Seismic Source Model, 2008; and ESA, 2008
**TABLE 4.4-1**

**ACTIVE REGIONAL FAULTS**

<table>
<thead>
<tr>
<th>Fault</th>
<th>Approximate Distance&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Fault Classification&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Maximum Credible Earthquake&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenville</td>
<td>4 miles west</td>
<td>Active</td>
<td>7</td>
</tr>
<tr>
<td>San Andreas</td>
<td>40 miles west</td>
<td>Active</td>
<td>8</td>
</tr>
<tr>
<td>Mount Diablo blind thrust</td>
<td>8 – 9.5 miles southwest</td>
<td>Active</td>
<td>6.8</td>
</tr>
<tr>
<td>Calaveras</td>
<td>18 miles west</td>
<td>Active</td>
<td>7</td>
</tr>
<tr>
<td>Hayward</td>
<td>21 miles west</td>
<td>Active</td>
<td>7.1</td>
</tr>
<tr>
<td>Pittsburg–Kirby Hills (Montezuma Hills)</td>
<td>13.5 miles north</td>
<td>Late Quaternary</td>
<td>6.6</td>
</tr>
<tr>
<td>Concord–Green Valley</td>
<td>15.5 miles northwest</td>
<td>Active</td>
<td>7.1</td>
</tr>
</tbody>
</table>

<sup>a</sup> Distance from Los Vaqueros Dam.  
<sup>b</sup> An "active fault" is defined by the California Geological Survey as one that has displayed displacement within the last 10,000 years. A "potentially active" fault is defined as a fault that has shown evidence of surface displacement within the past 1.6 million years. “Late Quaternary” refers to a fault with displacement in the last 700,000 years. The California DSOD fault activity guidelines (Fraser, 2001a) differentiate active seismic sources, conditionally active seismic sources, and inactive seismic sources. There are two subcategories of active seismic sources: Holocene active (within the last 11,000 years) and Latest Pleistocene (less than 35,000 years old but older than 11,000 years) active. The distinction between these two subcategories is descriptive, and both categories are treated as active seismic sources for design purposes. Inactive faults have had no surface or subsurface displacement in the last 35,000 years, and inactivity is demonstrated by fault traces that are consistently overlain by unbroken geologic materials that are older than 35,000 years.  
<sup>c</sup> The maximum credible earthquake is an estimated moment magnitude (M) for the largest earthquake capable of occurring on a fault.  

SOURCES: CCWD and Reclamation, 1993; Jennings, 1994; Petersen et al., 1996; Fraser, 2001a; URS and MWH, 2004.

(M 8.0 at 40 miles) could induce seismic deformations comparable to those on the Greenville Fault and therefore was also included as a controlling fault for design purposes (Woodward Clyde Consultants, 1995).

In addition, since the construction of the Los Vaqueros Dam, a new fault system, the Mount Diablo blind thrust, located about 12 miles southwest of the reservoir, has been identified. Blind thrust faults do not reach the earth’s surface and therefore are not as easily recognized as other faults. The MCE for the Mount Diablo blind thrust is M 6.8; therefore, the Greenville and San Andreas Faults remain the controlling faults for the reservoir expansion (URS and MWH, 2004).

For a small percentage of the dams worldwide, the weight associated with large deep reservoirs and the increased pore pressure has triggered small localized earthquakes. The induced earthquakes are often associated with initial filling of the reservoirs. The potential for reservoir triggered seismicity (RTS) was evaluated for the original Los Vaqueros Reservoir and considered to be low to moderate, with most of the activity likely to be experienced as relatively low magnitude events (Wong and Strandberg, 1996). The study determined that the MCE on the Greenville or San Andreas Faults would generally produce greater ground shaking than any local reservoir-induced event (Wong and Strandberg, 1996). Since the initial filling of Los Vaqueros Reservoir in 1998, no reservoir-induced seismicity has been observed. Like the original dam, the proposed dam modifications for the reservoir expansion would be designed to withstand activity on the two controlling faults and thus would be sufficient to withstand potential RTS activity.
**Seismic Hazards**

The project area could be affected by a major earthquake along seismically active or potentially active fault lineaments during the project life. The three major hazards associated with earthquakes are ground shaking, liquefaction, and settlement. Lateral spreading is also addressed in this section.

**Ground Shaking**

The amplitude and frequency content of ground shaking is related to the size of an earthquake, the distance from the causative fault, the type of fault (e.g., strike-slip), and the response of the geologic materials at the site. Ground shaking can be described in terms of acceleration, velocity, and displacement of the ground. As a rule, the greater the earthquake magnitude and the closer the fault rupture to a site, the greater the intensity of ground shaking. The ground shaking hazard has been estimated at Los Vaqueros Reservoir. The highest ground motions would be generated from a M 7.0 earthquake on the Greenville Fault. Given the relatively close distance to the fault (4 miles), the potential ground shaking is expected to be strong to very strong at the reservoir site if such an event occurs (ABAG, 2008) on this fault. In addition, because the San Andreas Fault can produce a very large earthquake, M 8.0, such potential ground shaking has also been addressed in design studies for Los Vaqueros Dam. The seismic design of the dam includes the modeled calculations of dynamic forces that could be expected from these controlling faults to ensure that the dam could withstand such forces.

**Liquefaction**

Liquefaction is an earthquake induced phenomenon in which loose to moderately dense saturated granular sediments temporarily lose their shear strength and become fluid-like. Liquefaction-induced phenomena include vertical settlement from densification, lateral spreading, ground oscillation, flow failures, loss of bearing strength, subsidence, and buoyancy effects. Susceptibility to liquefaction depends on the depth and density of the sediments and the magnitude of earthquake. Saturated, unconsolidated silts, sands, silty sands, and gravels within 50 feet of the ground surface are most susceptible to liquefaction.

The alluvial deposits throughout much of the project area do not pose a liquefaction hazard to the existing or to the proposed dam expansion and conveyance facilities. At the dam site, all alluvial materials from the dam foundation were removed during construction so that the dam is founded entirely on bedrock. Alluvial deposits within the reservoir or landslide deposits found around the reservoir rim that may be susceptible to liquefaction pose no hazard to the existing dam or to the proposed dam expansion because the dam will not be structurally founded on these deposits. The existing and proposed new intake locations along Old River are in areas with liquefaction potential; however these areas would be identified during design and treated during construction to mitigate the risk. Liquefaction potential for all project elements is further discussed below in the Environmental Consequences section.

**Settlement**

Ground surface settlement can be accelerated and accentuated by earthquakes. During an earthquake, settlement can occur as a result of the relatively rapid compaction and settling of surface materials—particularly loose, non-compacted and variable sandy sediments—due to the
rearrangement of soil particles during prolonged ground shaking. Saturated, unconsolidated sands and fine-grained sediments are associated with the deposits of the San Joaquin River and other low-gradient streams in the Great Valley geomorphic province. Settlement would generally be considered a lower potential for higher areas such as pipeline alignments within the upland regions and the embankments of the reservoir. The potential for settlement would be greatest in lowland areas such as the area of the Old River near the existing Old River Intake and the proposed new Delta Intake and Pump Station, where compressible alluvial sediments are thickest.

**Lateral Spreading**
Lateral spreading generally is a phenomenon where blocks of intact, non-liquefied soil move down slope on a liquefied substrate of large areal extent (Youd et al. 1978 and Tinsley et al. 1985). This condition is unlikely to be present around the rim of the reservoir but in any case would not present a threat to the existing dam or proposed dam expansion. As described above, the dam foundation is underlain by bedrock that is not susceptible to liquefaction or lateral spreading. In accordance with standard geotechnical practices, the potential for lateral spreading is considered along with liquefaction potential. The potential for lateral spreading affecting project facilities is discussed further below in the Impacts and Mitigation section.

**Soils**
Soils can have certain properties or limitations that need to be addressed with respect to their use for different purposes. These limitations include subsidence, shrink-swell potential, erosion potential, and corrosivity. Each of these constraints is discussed further with respect to potential occurrence in the project area.

**Subsidence**
Subsidence is the gradual lowering of the land surface due to compaction of underlying materials. Subsidence can occur as a result of hydrocompaction; groundwater, natural gas, and oil extraction; or the decomposition of highly organic soils. The proposed project does not include elements such as extraction of subsurface resources that would potentially cause subsidence. Therefore, the hazard of subsidence is not discussed further in this document.

**Shrink-Swell Potential**
Expansion and contraction of expansive soils in response to changes in moisture content can cause differential and cyclical movements that can cause damage and/or distress to shallow founded structures and equipment. Issues with expansive soils typically occur near the ground surface where changes in moisture content typically occur. Often times, grading, site preparations, and backfill operations associated with pipelines can eliminate the potential for expansion. The potential for shrink-swell conditions to affect the proposed project elements is further discussed in the Impacts and Mitigation section.

**Erosion**
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 site, areas that are susceptible to erosion are those that would be exposed during the construction phase and along the 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. Soil erosion is a potential issue at the proposed facility sites and is discussed in the Impacts and Mitigations section.

**Corrosivity**
Corrosivity refers to potential soil-induced electrochemical or chemical action that could corrode or deteriorate concrete, reinforcing steel in concrete structures, and bare-metal structures exposed to these soils. The rate of corrosion is related to factors such as soil moisture, particle-size distribution, and the chemical composition and electrical conductivity of the soil. The natural soils found along the pipeline alignments in the project area may be moderately corrosive. The materials used in the construction of modern pipelines are typically designed to resist the effects of corrosion over the design life of the pipeline. In addition, native soils are typically replaced by engineered backfill which generally has a low corrosive potential.

**Project Area Soils**
The project area soils are grouped into generalized soil associations that reflect the bedrock and various alluvial parent materials from which they are derived (Welch, 1977). The upland or bedrock soils belong to one soil association; the alluvial soils belong to five soil associations. Soil associations in the project area are shown on Figure 4.4-2. The characteristics of these soils are summarized in Table 4.4-2. The soils tend to be neutral to moderately alkaline; localized areas of alkaline soils and vegetation develop in some valley bottoms. The upland soils developed in sandstone and finer-grained bedrock belong to the Altamont-Diablo-Fontana soil association. These soils are strongly sloping to very steep with well-drained clay and silty clay loam textures and have slight to high erodibility.

The alluvial soils belong to five soil associations. The Brentwood-Rincon-Zamora soil association occurs along Kellogg Creek and the alluvial fans at the Coast Ranges to Great Valley transition zone. These soils are nearly level to gently sloping with well-drained clay loams and silty clay loams. The Capay-Sycamore-Brentwood, Sacramento-Omni, and Rindge-Kingile soil associations form on the lower-gradient, more fine-grained stream deposits or in organic materials derived from decaying plants; these soils occur downstream on progressively finer-grained and more poorly drained deposits. The Capay-Sycamore-Brentwood soil association ranges from moderately well-drained to poorly drained clays, silty clay loams, and clay loams on valley fill and floodplains. The Sacramento-Omni soil association is composed of nearly level poorly drained to very poorly drained clays and clay loams on the Delta and floodplains. The Rindge-Kingile soil association is on nearly level, very poorly drained surfaces composed of organic mucks adjacent to the Old River. The Capay-Rincon soil association consists of moderately well-drained and well-drained clays and clay loams.
TABLE 4.4-2
PROJECT AREA SOIL CHARACTERISTICS

<table>
<thead>
<tr>
<th>Soil Association/Soil</th>
<th>Shrink-Swell</th>
<th>Erodibility</th>
<th>Corrosivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altamont</td>
<td>High</td>
<td>Slight to High</td>
<td>High</td>
</tr>
<tr>
<td>Diablo</td>
<td>High</td>
<td>Slight to High</td>
<td>High</td>
</tr>
<tr>
<td>Fontana</td>
<td>Moderate</td>
<td>Slight to Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Brentwood</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Rincon</td>
<td>Moderate to High</td>
<td>Slight to Severe</td>
<td>Moderate to High</td>
</tr>
<tr>
<td>Zamora</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Sacramento</td>
<td>High</td>
<td>Low</td>
<td>Very high</td>
</tr>
<tr>
<td>Omni</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Rindge</td>
<td>High shrink, low swell</td>
<td>Very low</td>
<td>Very high</td>
</tr>
<tr>
<td>Kingile Muck</td>
<td>High shrink, low swell</td>
<td>Very low</td>
<td>Very high</td>
</tr>
<tr>
<td>Capay</td>
<td>Low</td>
<td>Slight</td>
<td>High</td>
</tr>
<tr>
<td>Sycamore</td>
<td>Moderate</td>
<td>Slight</td>
<td>High</td>
</tr>
<tr>
<td>Brentwood</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Capay</td>
<td>Low</td>
<td>Slight</td>
<td>High</td>
</tr>
<tr>
<td>Rincon</td>
<td>Moderate to High</td>
<td>Slight to Severe</td>
<td>Moderate to High</td>
</tr>
</tbody>
</table>


Mineral Resources

According to the identified mineral resource areas within the Contra Costa County (2005) and Alameda County (1994 and 2002) General Plans, the primary mineral resource areas are located outside of the study area (Contra Costa County, 2005 and Alameda County, 2002). The only exception is a deposit of Domengine sandstone located south of Camino Diablo and east of Vasco Road. The proposed Transfer-Bethany Pipeline in this area is located within Vasco Road and therefore would not interfere with the availability of this resource. In addition, no oil and gas operations exist in the project area. Potential project facilities do not fall within any areas identified as mineral resource areas. Therefore, the project alternatives would not result in the loss of availability of any known mineral resource, or interfere with any existing commercial mining activity. No impacts to mineral resources would occur and no further evaluation is included in this document.

4.4.2 Environmental Consequences

Methodology

This analysis considers the potential of the Los Vaqueros Reservoir Expansion Project and alternatives to interact with the local geologic environment to produce conditions that would exceed the applied significance criteria identified below.
Significance Criteria

The thresholds for determining the significance of impacts for this analysis are based on the environmental checklist in Appendix G of the State CEQA Guidelines and professional judgment of the EIS/EIR preparers. These thresholds also encompass the factors taken into account under NEPA to determine the significance of an action in terms of its context and the intensity of its effects. An alternative was determined to result in a significant impact if it would do any of the following:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, strong seismic ground shaking, or seismic-related ground failure, including liquefaction and landslides
- Result in substantial soil erosion or the loss of topsoil
- Be located on a geologic unit or soil that is unstable or would become unstable as a result of the project, and potentially result in onsite or offsite landslides, lateral spreading, subsidence, liquefaction, or collapse, creating substantial risks to life or property; or be located on an expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1995), 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

The project would not expose people or structures to injury, death, or damage from fault rupture because none of the proposed project components intersect any active faults, as determined by California Geological Survey mapping performed in accordance with the Alquist-Priolo Earthquake Fault Zoning Act. Accordingly, fault rupture is not discussed further in this section.

Soils that are susceptible to collapse are typically found in regions outside of the project area. Collapsible soils are most often encountered in arid climates, where wind and intermittent streams deposit loose low-density materials. When placed under new loading or the addition of water that reaches deeper than under normal conditions, these soils can collapse causing structural damage. However, these conditions or soils are not found in the study area and therefore there is no potential for collapsible soils and it is not discussed further in this section.

As discussed above in the setting section, lateral spreading is a hazard that is associated with liquefaction. Therefore, where the impact discussion below refers to potential liquefaction hazards, it addresses any potential lateral spreading hazards.

At the Los Vaqueros Reservoir day-use areas, wastes and wastewater from the public restrooms and other facilities are regularly pumped and captured in a holding tank and hauled offsite by a contractor for treatment. Because there are no septic systems to be evaluated, there is no further discussion of soil capability related to septic tanks or alternative wastewater disposal systems.

Impact Summary

Table 4.4-3 provides a summary of the impact analysis for issues related to geology, soils, and seismicity.
### 4.4 Geology, Soils, and Seismicity

#### TABLE 4.4-3
**SUMMARY OF IMPACTS – GEOLOGY, SOILS, AND SEISMICITY**

<table>
<thead>
<tr>
<th>Impact</th>
<th>Project Alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.4.1: The project facilities would be designed and engineered in accordance with seismic code requirements. As a result, the project would not expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving strong seismic ground shaking or seismic-related ground failure, including liquefaction and landslides.</td>
<td>LS</td>
</tr>
<tr>
<td>4.4.2: During construction and operations, the project could result in substantial soil erosion or the loss of topsoil.</td>
<td>LSM</td>
</tr>
<tr>
<td>4.4.3: Project components could be located on expansive or corrosive soils or on a geologic unit or soil that is unstable or could become unstable as a result of the project or construction activities; however, those components would not likely result in onsite or offsite landslides, lateral spreading, subsidence, liquefaction, or collapse, and would not create substantial risks to life or property.</td>
<td>LS</td>
</tr>
<tr>
<td>4.4.4: The proposed project would not make a cumulatively considerable contribution to cumulative effects associated with erosion, topsoil loss or increased exposure to seismic or other geohazard risks.</td>
<td>LS</td>
</tr>
</tbody>
</table>

**SU = Significant and Unavoidable**

**LSM = Less-than-Significant Impact with Mitigation**

**LS = Less-than-Significant Impact**

**NI = No Impact**

---

**Impact Analysis**

**No Project/No Action Alternative**

Under the No Project/No Action Alternative, no new facilities would be constructed. Therefore, this alternative would have no impact associated with geological hazards or soil erosion. All of the geotechnical hazards described in Section 4.4.1, Affected Environment would remain as under existing conditions. The No Project/No Action Alternative would not create any conditions to increase those hazards or result in risks to people, structures, or the environment.

**Impact 4.4.1:** The project facilities would be designed and engineered in accordance with seismic code requirements. As a result, the project would not expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving strong seismic ground shaking or seismic-related ground failure, including liquefaction and landslides. (Less than Significant)

**Alternative 1**

This alternative includes many elements of new construction, modification, and expansion of existing facilities. These proposed facilities extend over a range of geologic materials and environments from saturated, unconsolidated sands and fine-grained deposits of the Delta to bedrock deposits of
the Panoche Formation as described above in the setting section. Seismic effects can vary depending on underlying geologic materials and conditions. Therefore, the potential seismic impact is presented below by proposed facility or project component.

**Los Vaqueros Reservoir Expansion/Dam Modification**

**Ground Shaking.** Active faults capable of producing strong ground motions are located near the dam and the dam related facilities, which could experience a major earthquake within the operational life of the project. However, the proposed modifications to the dam would be designed according to the latest seismic design standards. Strong ground motion at Los Vaqueros Reservoir and the corresponding response of the dam has been calculated to potentially cause structural deformation of the dam on the order of 1 to 2 feet but would not result in the uncontrolled release of water from the reservoir. The spillway and inlet/outlet structure would be designed to be fully operational after the earthquake.

The existing Los Vaqueros Dam is a well-compacted zoned-earthfill embankment dam that has performed well since the reservoir was first filled 10 years ago. No significant issues have developed with internal pressures, seepage, or deformation in either the embankment or its foundation, and the dam continues to perform well within the parameters set during the design.

Under Alternative 1, the Los Vaqueros Dam, spillway and inlet/outlet structure would be designed to accommodate the maximum credible ground motion for the site, determined from a detailed seismic hazard study that would evaluate all faults that could conceivably affect the dam. A very conservative approach would be taken in the engineering and design to raise the Los Vaqueros Dam. The enlarged dam would be designed in accordance with standard industry practices, codes, and standards that been developed and proven over many decades, and have evolved from practical experience at dams where performance limits have been exceeded. Multiple lines of defense or design redundancy will be incorporated into the design, and protective features will be used to counter potential adverse conditions that might occur. Conservative safety factors will be applied to the design to compensate for uncertainties in features such as the geologic conditions at the site, variability in the properties of soils in the dam, and the magnitudes of flood and seismic hazard risks. As part of the design, the dam modifications would be founded directly onto underlying bedrock. The design would include site-specific investigations and development of project-specific design criteria based on site-specific geologic and seismic hazards, including fault rupture, ground motions generated by earthquakes, slope instability, and liquefaction. The materials and internal zoning of the dam will produce a structure that is very tolerant to seismic deformation and will safely resist the maximum credible earthquake. The engineering, and the plans and specifications will be carefully reviewed by DSOD and an independent review board at multiple stages during the design. Following completion of the project, DSOD will issue a certificate of approval to operate the reservoir once they are satisfied the dam has been constructed in conformance with the approved plans and specifications and that the design intent has been met.

**Liquefaction and Landslides.** All alluvial materials from the dam foundation were removed at the dam location during the original dam construction so that the dam is founded entirely on
4.4 Geology, Soils, and Seismicity

bedrock. There is no evidence that the alluvial deposits within the reservoir or landslide deposits found around the reservoir rim contain materials susceptible to liquefaction (Ellen et al., 1997; Pike, 1997). In any case, liquefaction of material within the reservoir poses no hazard to the existing dam or to the proposed dam expansion because all liquefiable materials that could potentially affect the dam were previously removed.

Landslides have been identified and mapped by the United States Geological Survey (USGS) in a couple of different Bay Area wide studies of debris flows and landslides (Ellen et al., 1997; Pike, 1997). Similar to engineering design measures implemented for the existing Los Vaqueros Reservoir (Fraser, 2001b; Simpson and Schmoll, 2001), adherence to CCWD standards will include measures (including excavation to a stable base) to minimize the risk of landslides due to heavy precipitation or ground shaking. Regardless, no major or rapid landslides have been previously identified at the site; consequently, the risk of damage to the dam or nearby workers or users from rapid landsliding is considered very small.

**Delta Intake Facilities**

**Ground Shaking.** The Delta intake facility improvements under this alternative would consist of constructing a new Delta Intake and Pump Station just south of the existing intake along Old River. The geologic conditions and hazards in this area include thick alluvial deposits that are susceptible to amplified ground shaking during a significant seismic event. Typically construction on these types of geologic materials requires geotechnical considerations to ensure that seismic stability is incorporated into design and carried through during construction. Whereas the intake facilities would primarily be controlled remotely and thus presenting little risk to any workers, CCWD standards still require that the design be sufficient to withstand anticipated ground shaking during a major seismic event. Common foundation recommendations such as deep foundation systems that anchor the foundation to deeper more competent materials or placement of stockpiles on building site (surcharging) to create more competent materials are proven methods of geotechnical mitigations that can minimize the potential damage from ground shaking. CCWD construction requirements include seismic design measures that incorporate site specific data such as engineering properties of underlying geologic materials and distance to active faults to create site specific seismic code requirements to ensure the safety and integrity of the structure. A geotechnical investigation would provide the necessary site specific data and information.

**Liquefaction and Landslides.** The proposed new Delta Intake and Pump Station is underlain by thick alluvial materials that are considered to have a high liquefaction potential (Knudsen et al., 2000). A geotechnical investigation would include an evaluation of liquefiable materials. The subsurface conditions in the siting zone for the Delta Intake and Pump Station are expected to include a series of fine sands, silts, clays, and peat that are susceptible to liquefaction. Accordingly, the facility would need to be supported on a foundation system such as driven concrete or steel piles as was used for the existing Old River Intake and Pump Station. These driven piles allow for above ground improvements and even pipelines to be founded on more stable non-liquefiable layers at depth. For purposes of this EIS/EIR impact analysis, it is assumed that piles would be driven to an approximate elevation of -50 feet msl and spaced about 15 feet apart on a square grid. In addition to the piles, stone columns would be used to densify the soil in the area around the intake.
structure to reduce the liquefaction potential of the soil and to improve its lateral strength during seismic events.

The proposed new Delta Intake and Pump Station is located adjacent to Old River on the valley floor. The proposed building site and surrounding area are relatively flat, which makes the landslide potential very low. Therefore, no on or off-site landslides are anticipated to affect or be affected by the proposed intake facility.

**Conveyance Facilities**

Construction of project pipelines under Alternative 1 would primarily use the open-trench method, as shown on Figure 3-25, Pipeline Construction Schematic. The Transfer-Bethany Pipeline would involve some tunnel construction at the southern end. The other proposed conveyance facilities include the Delta-Transfer Pipeline, the Transfer Facility Expansion, the Transfer-LV Pipeline, the Inlet/Outlet Pipelines, the Transfer-Bethany Pipeline, and the blow off and air valves associated with each pipeline.

**Ground Shaking.** As described above, the project area is located in a seismically active region. All the conveyance facilities described above extend across a wide range of geographical and geological environments. Ground shaking effects typically differ among varying geologic materials in addition to other factors such as distance to earthquake epicenter and magnitude of event. In general, ground shaking at locations underlain by bedrock is experienced as sharp but short-lived ground motions whereas thick soft alluvial sediments can amplify ground motions and cause longer periods of shaking. Typically, buried conveyance facilities are at less risk of damage from ground shaking than above ground structures. Modern construction materials combined with appropriate geotechnical engineering such as compacted engineered fill surrounding buried conveyance facilities can minimize the potential for damage. CCWD construction requirements are designed to ensure that conveyance facilities are constructed to withstand anticipated ground shaking.

**Liquefaction and Landslides.** Liquefaction potential varies across the project area with areas of high susceptibility and those of very low susceptibility. In general, in areas underlain by bedrock or upland regions where groundwater is deep, there is a very low potential for liquefaction. Liquefaction potential is high along upper Kellogg Creek and on the deposits within the San Joaquin Valley (Knudsen et al., 2000). Therefore, the Delta-Transfer Pipeline and the Transfer-LV Pipeline would be located or at least partially located in areas where there is a high potential for liquefaction. In general, buried pipelines can be particularly susceptible to damage as a result of liquefaction if not appropriately engineered. As previously mentioned, evaluating the potential for liquefaction is a standard practice for geotechnical engineering and therefore the design of all conveyance facilities will include an analysis for liquefaction. If present, the geotechnical investigation reports will include engineering recommendations to minimize the potential for damage to the conveyance facilities. Typical engineering measures include removal of liquefiable materials, soil treatments, and replacement with engineered fill materials. Standard geotechnical and engineering design procedures would minimize the potential for these soils to affect the conveyance facilities.
The Delta-Transfer Pipeline is located in a relatively flat region that has little likelihood of being impacted by landslides. Both the Transfer-LV Pipeline and the Transfer-Bethany Pipeline, however, would include upland locations with steeper terrain. According to USGS mapping, no known landslides have been identified along any of the proposed pipeline routes (Ellen et al., 1997; Pike, 1997). Tunneling proposed as part of construction of the Transfer-Bethany Pipeline would be accomplished according to CCWD standards, which include measures for addressing potential slope failures. Slope stability would be most important during the construction phase as the tunnel would be shored for the purposes of installing the pipeline. Once installed and appropriately backfilled according to CCWD standards, the potential for landslides or slope failures to impact the pipeline would be minimized.

**Power Supply Infrastructure**

There are two power options proposed under Alternative 1. Under Power Option 1, power supplied to the new Delta and/or Old River Intake and Pump Stations would include using an existing 230 kV transmission line from the Tracy Substation adjacent to the Central Valley Project (CVP) Jones Pumping Plant. A new Western substation, installed at the eastern terminus of Camino Diablo Road, would step power down from the 230 kV line to 69 kV. From the substation, an existing 69 kV power line to the Old River Pump Station would be upgraded, replaced, or have an additional line added. For the Expanded Transfer Facility, a new 21 kV distribution line would be installed from the new substation, paralleling the existing 230 kV line until it intersects the Delta-Transfer Pipeline, at which point the distribution line would be installed within the pipeline alignment. See Figure 3-20 in Chapter 3, Project Description. Impacts along this alignment are analyzed above, under Conveyance Facilities.

Regarding Power Option 2, additional power supplied to the New Delta and/or Old River Intake and Pump Stations would entail construction of a new 69 kV power line which would be constructed from the Western substation south of the Harvey O. Banks Pumping Plant to the intersection of the existing 69 kV power line. The existing power line would be upgraded, replaced, or have an additional line added. Additional power supplied to the Expanded Transfer Facility would include construction of a new Pacific Gas & Electric (PG&E) distribution substation located within the Los Vaqueros Watershed. The substation would step power down from an existing 230 kV transmission line to 21 kV. From the proposed PG&E substation, a new distribution line would traverse west and then north following an existing alignment to the Expanded Transfer Facility.

**Ground Shaking.** All new construction and expansion of existing facilities required for either Power Options 1 or 2 would be accomplished according to the recommendations of geotechnical investigations. In general, power lines are designed to withstand the effects of high winds; these design features would also accommodate the effects of any potential ground shaking. Regardless, all proposed facilities would be designed according to the recommendations of geotechnical investigations, which are prepared by state licensed professionals. Incorporation of these site-specific recommendations into the design according to industry standard construction requirements would reduce the potential damage to any improvements. Current requirements include measures for calculating foundation design specifications to ensure that these improvements can withstand anticipated ground shaking. In addition, Western and PG&E have
their own internal construction requirements that meet or exceed the IBC and California Public Utilities Commission requirements.

Impacts associated with the construction and operation of either the Western or PG&E substation or all the new power/distribution lines would be less than significant with adherence to the industry standard design requirements and standard practices for construction of power/distribution lines.

**Liquefaction and Landslides.** As previously discussed, liquefaction potential varies across the project area. The proposed Western and PG&E substations and the power line alignment are located in an area considered to have a high potential for liquefaction. As also discussed, industry standard geotechnical practices would ensure that proposed power supply facilities would be constructed with appropriate measures such as IBC requirements to address any potential liquefaction hazards, if present. Such measures could include soil treatment or replacement with engineered fill.

**Recreational Facilities**

New dam construction and the expanded reservoir capacity would require the replacement of marina facilities, including a Marina Complex with a residence for the Marina Manager, Interpretive Center, fishing piers, parking areas, picnic facilities, access roads, and hiking trails.

**Ground Shaking.** Similar to the aforementioned improvements, all new construction for the proposed recreational facilities would be accomplished according to the recommendations of geotechnical investigations. The geotechnical investigations, conducted by state licensed professionals, would include recommendations for design criteria based on anticipated ground shaking in accordance with CCWD requirements. These requirements include seismic design criteria that when followed would prevent any of these proposed recreational facilities from collapse or significant structural damage. Public safety is at the forefront in the development of these codes which incorporate decades of research and study of performance of structures during significant seismic events that have occurred all over the world. Incorporation of these site-specific recommendations into the design would reduce the potential damage to any improvements.

**Liquefaction and Landslides.** In the area of the proposed recreational facilities, bedrock is either at the surface or at shallow depths beneath the surface. The liquefaction potential of the bedrock areas is mapped as very low (Knudsen et al., 2000). The proposed fishing piers, however, would be partially located above saturated reservoir sediments that could potentially liquefy. Generally, posts constructed for piers are anchored at depth beneath any liquefiable materials. Regardless, prior to construction, these facilities would undergo a geotechnical investigation and appropriate structural design according to CCWD construction requirements to ensure that they are not susceptible to significant damage from liquefaction.

The proposed recreational facilities are located in areas that are relatively flat or are not within known landslides or debris flows (Ellen et al., 1997; Pike, 1997). The geotechnical investigations completed above would also include site specific investigations to ensure that structures are not at risk of any landslides or debris flows. CCWD construction and grading requirements include measures for limiting the potential for slope failure associated with new construction.
Summary

Alternative 1 includes a variety of proposed improvements that are all located within a seismically active region. All proposed facilities are subject to potential ground shaking but none are likely to be affected by surface fault rupture. The potential for liquefaction or landslide hazards to impact the proposed facilities varies by location as described above. To minimize the potential for damage related to ground shaking and ground failure (including landslides and liquefaction), Los Vaqueros Dam and associated improvements (i.e. spillways, inlet/outlet works, Oxygenation System) would be designed and constructed in accordance with industry standard practices and other CCWD construction requirements. The foundations of other facilities including the new Delta Intake and Pump Station, conveyance facilities, powerlines, and recreational facilities would be designed in accordance with industry standard practices Pipelines would be designed to include flexible connections, where deemed necessary, along with backfill requirements that minimize the potential for significant damage. All other project buildings and structures would employ standard design and construction for structures using the most recent geotechnical practices and CCWD seismic criteria, which would provide conservative design criteria. Therefore, the potential impact from strong seismic ground shaking or seismic-related ground failure, including liquefaction and landslides, would be less than significant.

Alternative 2

This alternative would include all of the same facilities that are described above in the analysis for Alternative 1.

Alternative 3

This alternative would include all of the same facilities that are described above in the analysis for Alternative 1 with two exceptions. Alternative 3 does not include the new Delta Intake and Pump Station or the Transfer-Bethany Pipeline. These omissions would not result in any significant reduction of impacts related to seismic activity other than the fact that there would be overall less facilities constructed that would be at risk of damage following a significant earthquake. The expansion of the Old River Intake would occur within the existing facility site and therefore would require a reduced geotechnical engineering effort. The remaining proposed improvements under Alternative 3, as under Alternative 1, would be similarly constructed according to standard industry practices and CCWD building requirements that would reduce the potential impacts from seismic activity to less than significant levels.

Alternative 4

Alternative 4 would require significantly less construction of new facilities compared to Alternative 1. There would be no physical expansion of the Transfer Facility, no new Delta Intake and Pump Station, and no new pipelines or power supply infrastructure. The reduction in new construction would result in fewer improvements susceptible to the effects of seismic activity, and all improvements would be constructed according to CCWD construction standards that would reduce the potential impacts from seismic activity to less than significant levels. The dam and reservoir would still undergo expansion but would also be similarly constructed according
to standard industry practices and CCWD construction requirements that would reduce the potential impacts from seismic activity to less than significant levels.

**Mitigation:** None required.

---

**Impact 4.4.2:** During construction and operations, the project could result in substantial soil erosion or the loss of topsoil. (Less than Significant with Mitigation)

**Alternative 1**

**Los Vaqueros Reservoir Expansion/Dam Modification**

The proposed expansion of Los Vaqueros Reservoir would require the excavation, transport, stockpiling, grading, drilling, blasting, and use of a substantial quantity of bedrock, alluvium, and soil obtained from the borrow area. Other activities include the demolition and removal of existing facilities within the inundation zone and the installation of support structures and new access roads. Equipment and vehicle staging areas would also be required. Construction activities with the potential for sediment delivery to Kellogg Creek include fill placement on the downstream face, the concrete plant and the fill stockpiles downstream of the dam. Also, a 15-acre stockpiling/staging area would be located downstream of the dam. If managed correctly, the soils disturbed by project earthwork and construction activities as well as stockpiled materials for use in the construction would not be susceptible to water induced erosion and loss of topsoil.

Once the new dam is constructed and the reservoir filled, 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.

**Delta Intake Facilities**

Alternative 1 would include construction of a new Delta Intake and Pump Station. The new Delta Intake and Pump Station facility would include a water intake structure, pumping station facilities, a facilities building, a surge tank, and access road. Ground-disturbing activities within the 22-acre site would be required for site preparation and foundation construction of the proposed facility. The soils disturbed by earthwork and construction activities at this facility as well as stockpiled materials for use in the construction would be susceptible to the effects of wind or water induced erosion and loss of topsoil.

**Conveyance Facilities**

The conveyance facilities under Alternative 1 would include significant earthwork and grading activities during construction. Construction of the pipelines would primarily use the open-trench method; however, the Transfer-Bethany Pipeline also includes an approximately 0.8-mile or 1.5-mile tunneled section of pipeline. In areas where the proposed pipeline alignments would be located where there is little topographic variance, such as much of the Delta-Transfer Pipeline alignment, the potential for significant soil erosion is generally much lower. However, for other areas with
steeper terrain, erosion potential is higher. Soils disturbed by earthwork and construction activities for these conveyance facilities as well as stockpiled materials for use in the construction would be susceptible to the effects of wind or water induced erosion and loss of topsoil.

**Power Supply Infrastructure**

Construction of the transmission lines and a substation under Alternative 1 would result in ground breaking activity under either of the two power options. A new substation would be developed under either Power Option 1 and 2 (a new Western substation near Camino Diablo under Option 1 and a new PG&E substation near the Transfer Facility under Option 2), and would involve permanent development of an approximately 2-acre site and a permanent access road. Construction of these facilities would require temporary grading and earthwork that would disturb subsurface soils where the new substation, access and power lines would be installed. Soils disturbed by earthwork and construction activities for these conveyance facilities as well as stockpiled materials for use in the construction would be susceptible to the effects of wind or water induced erosion and loss of topsoil.

**Recreational Facilities**

The construction of recreational facilities would require ground disturbance and earthwork. Soils disturbed by earthwork and construction activities for these conveyance facilities as well as stockpiled materials for use in the construction would be susceptible to the effects of wind or water induced erosion and loss of topsoil.

**Summary**

Construction of all the proposed improvements under Alternative 1 would include earthwork and grading activities that would disturb large volumes of soil. If not managed correctly, these soils could be susceptible to the effects of wind or water induced erosion and loss of topsoil would be a significant impact. The expanded inundation area, however, would not result in significant erosion based on past performance and the physical conditions which would contain any eroded materials.

**Alternative 2**

Alternative 2 would include all of the same facilities as in Alternative 1 and therefore potential erosion impacts would be the same as those described for Alternative 1. This impact is significant.

**Alternative 3**

Alternative 3 includes most of the same facilities that are described in Alternative 1 with two exceptions. Alternative 3 does not include the new Delta Intake and Pump Station or the Transfer–Bethany Pipeline. It does include expansion of Old River Intake and Pump Station, however this would not require any groundbreaking activities. Without the two facilities included in Alternative 1, the total amount of earthwork and grading activities would be reduced and result in an overall lower potential for total erosion and loss of topsoil. However, potential erosion and topsoil loss would be a significant impact.
Alternative 4

Alternative 4 would require significantly less construction of new facilities compared to Alternative 1. There would be no physical expansion of the Transfer Facility, no new Delta Intake and Pump Station, and no new pipelines or power supply infrastructure. The proposed expansion of Los Vaqueros Reservoir to 160 TAF under this alternative would also require the excavation, transport, stockpiling, grading, drilling, blasting, and use of a substantial quantity of bedrock, alluvium, and soil; however, the total volume would be less. There also would be less recreational facility relocation and construction under this alternative. Although the total amount of earthwork activities and, consequently, the amount of soils exposed to erosion would be less under Alternative 4 compared to Alternative 1, the construction activities would still potentially expose soils to erosion, which would be a significant impact.

During operation of Alternative 4, the expanded reservoir would expose some soils to shoreline erosion along the zone of reservoir-elevation fluctuation, however as noted for Alternative 1, it is not expected to be significant. The 160 TAF expanded reservoir would have a shoreline of approximately 18.9 miles as opposed to the 24.7-mile shoreline under Alternative 1. Any sediment that erodes into the reservoir would be retained behind the dam.

Mitigation Measure

Implementation of mitigation hydrology measures (Measures 4.5.1a and 4.5.1b) and biological mitigation measures (Measures 4.6.2a and 4.6.2b) would reduce potential impacts of soil erosion and topsoil loss to a less-than-significant level. No additional measures would be required.

Impact Significance After Mitigation: These measures that control erosion and water quality of storm water runoff would be effective in reducing the potential for soil erosion and loss of topsoil to less than significant levels. Although these measures are primarily designed to prevent water quality impacts of receiving waters, they are achieved by reducing the potential for substantial erosion and loss of topsoil.

Impact 4.4.3: Project components could be located on expansive or corrosive soils or on a geologic unit or soil that is unstable or could become unstable as a result of the project or construction activities; however, those components would not likely result in onsite or offsite landslides, lateral spreading, subsidence, liquefaction, or collapse, and would not create substantial risks to life or property. (Less than Significant)

Alternative 1

Los Vaqueros Reservoir Expansion/Dam Modification

Landslides. The proposed modifications to the existing dam would include raising the dam crest to accommodate the reservoir expansion. Previous work at the dam site included removing unstable soils beneath the dam and placing the abutments on bedrock. The modifications to the dam would be similarly constructed on the Panoche Formation of sandstone and claystone (Wagner et al,
1990; Simpson and Schmoll, 2001). At the dam location, landslides have been identified and mapped (URS and MWH, 2004), however similar to the engineering design measures implemented for the existing Los Vaqueros Reservoir (Fraser, 2001b; Simpson and Schmoll, 2001), measures would be identified for any known or suspected slide areas, including excavation to a stable base and drainage improvements to maintain stability. Design of the dam, as required by DSOD must consider not only dynamic or seismic forces, as discussed above in Impact 4.4.1, but also static forces such as water pressure from reservoir storage, slope stability, and subsidence. With implementation of required dam design and engineering procedures there would not be a substantial risk to life or property associated with landslides at the dam or reservoir site.

**Subsidence.** The enlarged dam including all appurtenant facilities will be founded entirely on competent bedrock and consequently subsidence is not an issue.

**Expansive soils.** The enlarged dam including all appurtenant facilities will be founded entirely on competent bedrock and consequently expansive soils are not an issue.

**Corrosive soils.** The site soils are generally considered corrosive (Montgomery, 1992). The enlarged dam will be founded on bedrock and constructed largely with local materials; Panoche Formation claystone from the right abutment and alluvial clay from the valley floor. Materials imported to site such as the sands and gravels that comprise the dam’s internal drainage system will be tested for pH prior to acceptance on the job as was done during construction of the existing dam. Any imported materials that are potentially corrosive will not be used in the dam. Corrosion protection of metal fixtures exposed to the reservoir water or groundwater will be addressed during design and could include cathodic protect, electrical isolation and the use of stainless steel. Therefore since the dam will be largely constructed of materials already present at the site, imported materials will be non-corrosive and design measures will be used to mitigate against corrosion, the potential for corrosion is at less than significant levels.

**Delta Intake Facilities**

**Landslides.** The proposed new Delta Intake and Pump Station would be just south of the existing Old River Intake and Pump Station along Old River. The topography of this area is relatively flat with little likelihood of any landslides affecting the proposed facilities. The new levee that would surround the facility would be designed in accordance with current CCWD construction requirements by state licensed professionals that would ensure stability.

**Subsidence.** The underlying geologic materials alongside Old River consist of soft alluvial sediments that are susceptible to subsidence if not engineered appropriately. Industry standard geotechnical measures such as surcharging or pre-loading soft materials to accelerate the compression or installation of a deep foundation system on deeper more competent materials are effective means to overcome the potential for subsidence.

**Expansive soils.** According to the Soil Survey for Contra Costa County, the area of the proposed Delta Intake and Pump Station is shown as underlain by Kingile Muck. These deposits are considered to have a high expansion potential (Welch, 1977). The geotechnical measures
incorporated to address subsidence would also be effective in reducing the potential for expansive soils to impact any new intake facilities.

**Corrosive soils.** The native soils at the new Delta Intake and Pump Station are mapped as Rindge and Kingile soils which have a very high potential for corrosivity. However, modern construction materials and other engineering controls such as cathodic protection and use of engineered fills would effectively reduce the potential for corrosion to less than significant levels.

**Conveyance Facilities**

**Landslides.** The conveyance facilities would be located over a range of topographic environments from the lowlands of the Delta-Transfer Pipeline to the steeper terrain associated with the Transfer–LV Pipeline and Transfer-Bethany Pipeline. Generally, the installation of pipelines does not represent significant loads that can cause an otherwise stable geologic unit to result in a landslide. However, during construction, the disturbance from earthwork activities can potentially trigger slope failures if not engineered appropriately.

**Subsidence.** The various conveyance facilities proposed cover a wide range of soils and bedrock that would include some soft alluvial sediments susceptible to subsidence if not engineered appropriately. Industry standard geotechnical measures such as placement of compacted backfill surrounding the pipeline is an effective means to overcome the potential for subsidence.

**Expansive soils.** The conveyance facilities would be located across a range of soils having a range of expansion potential including those with a high expansion potential (Welch, 1977). Common geotechnical practices such as the placement of compacted engineered fill with a low expansion potential is effective in reducing the potential for expansive soils to impact any new intake facilities.

**Corrosive soils.** Previous soil surveys in both Contra Costa County and Alameda County have indicated that native soils with high corrosive potential are located throughout the project area. However, modern construction materials and other engineering controls such as cathodic protection and use of engineered fills would effectively reduce the potential for corrosion to less than significant levels.

**Power Supply Infrastructure**

**Landslides.** The majority of the power supply improvements such as the power lines and expanded Transfer Facility are located in areas that are either relatively flat or within gently rolling hills. The potential for landslides to affect the power supply infrastructure under either power option is low. In addition, both Western and PG&E have internal construction standards that must meet the requirements of the California Public Utilities Commission as well as the IBC.

**Subsidence.** The proposed new Western substation would be located in clayey alluvial soils of the Sacramento soils unit whereas the PG&E substation would be located in the Altamont soils unit. The proposed power supply lines would cover a range of different soil units. Depending on site specific conditions, these soils could potentially be susceptible to subsidence. The Western
substation location is likely to have a greater potential considering its location that is closer to the thick alluvial deposits of the valley floor. However, the potential for subsidence would be part of the industry standard analysis of geologic hazards. Industry standard geotechnical measures such as replacement of compacted backfill in the upper soil layer is an effective means to overcome the potential for subsidence. In addition, both Western and PG&E have internal construction standards that must meet the requirements of the California Public Utilities Commission as well as the IBC.

**Expansive soils.** Both the Altamont and Sacramento soils units have a high potential for expansion or shrink-swell characteristics. Common geotechnical practices and industry standards for installation of power poles such as the placement of compacted engineered fill with a low expansion potential is effective in reducing the potential for expansive soils to impact any new intake facilities.

**Corrosive soils.** Corrosive soils generally do not impact power poles and the substation improvements would be located on a foundation pad that would not be significantly impacted by corrosivity. Use of engineered fills would also be effective in reducing the potential impact from any corrosive soils, if present.

**Recreational Facilities**

**Landslides.** If rapid landsliding occurred due to either heavy precipitation or construction activities, recreational facilities or users could be exposed to landslide hazards if not given geotechnical engineering considerations. However, the proposed recreation facilities would not be located in an area where this risk would be likely to occur. The proposed recreational facilities are located in areas that are relatively flat or are not within known landslides or debris flows (Ellen et al., 1997; Pike, 1997). In addition, the geotechnical investigations required for the design of these improvements would require an analysis of the potential landslide hazard and implementation of measures to minimize risks to structures and people.

**Subsidence.** The majority of the proposed recreational facilities would be located on relatively thin soils above competent bedrock. The probability of subsidence in these areas is low; however, as is standard practice for the design of such structures, the site specific characteristics of the underlying materials would be evaluated. There is likely a greater potential for subsidence in the soft sediments within the reservoir where the fishing pier would be located. However, the piers would be anchored to more competent materials at depth which would mitigate the potential for subsidence to occur.

**Expansive soils.** All of the recreational facilities would be located on the Altamont soils association which has a high potential for expansion or shrink-swell characteristics. Some of the proposed facilities such as picnic areas and restrooms would likely be too light to be significantly impacted by expansive soils. Nonetheless, common geotechnical practices and industry standards for construction such as the placement of compacted engineered fill with a low expansion potential is effective in reducing the potential for expansive soils to impact any new Recreational Facilities.
**Corrosive soils.** The proposed recreational facilities generally do not include any elements such as pipelines that would be impacted by corrosive soils. Regardless, the use of engineered fills would also be effective in reducing the potential impact from any corrosive soils, if present.

**Summary**

The project area includes areas with soils and geologic units that have a potential for becoming unstable or causing damage if not appropriately engineered. Areas around the dam have the potential for landslides, the soft thick sediments of the valley floor, especially adjacent to Old River have a high potential for subsidence, and across the entire study area there are native soil units that are considered by the Soil Conservation Service to have a high potential for expansion and corrosion. All proposed improvements would require the initial preparation of a site specific geotechnical investigation which would identify potential geologic hazards such as landslides, subsidence and expansive/corrosive soils. Adherence to CCWD construction requirements and industry standard geotechnical practices would reduce potential impacts to a less-than-significant level.

**Alternative 2**

Proposed facilities and improvements under Alternative 2 would be the same as in Alternative 1. The proposed improvements would be constructed according to industry standard practices, and CCWD construction standards, that would reduce the potential impacts from seismic activity to less than significant levels.

**Alternative 3**

Alternative 3 includes most of the same facilities that are described in Alternative 1 with two exceptions. Alternative 3 does not include the new Delta Intake and Pump Station or the Transfer–Bethany Pipeline. This alternative does include expansion of the Old River Intake and Pump Station, however the expansion will not require groundbreaking activities and therefore would not be impacted by expansive soils. The remaining proposed improvements under Alternative 3, as under Alternative 1, would be similarly constructed according to industry standard practices, and CCWD construction standards that would reduce the potential impacts from unstable soils or geologic units to less than significant levels.

**Alternative 4**

Alternative 4 would require less construction of new facilities compared to Alternative 1. There would be no physical expansion of the Transfer Facility, no new Delta Intake and Pump Station, and no new pipelines or power supply infrastructure. This alternative also requires less relocation and construction of new recreation facilities. The project area includes areas with soils and geologic units that have a potential for becoming unstable or causing damage if not appropriately engineered. Areas around the dam have the potential for landslides. All proposed improvements would require the initial preparation of a site specific geotechnical investigation which would identify potential geologic hazards such as landslides, subsidence and expansive soils. Adherence to CCWD construction
requirements and industry standard geotechnical practices would reduce potential impacts to a less-than-significant level.

**Mitigation:** None required.

**Cumulative Effects**

**Impact 4.4.4:** The proposed project would not make a cumulatively considerable contribution to cumulative effects associated with erosion, topsoil loss or increased exposure to seismic or other geohazard risks. (Less than Significant)

Under all alternatives, surface areas disturbed during construction would be restored – either re-vegetated, compacted and/or paved. Cumulative erosion effects might arise if other projects would be constructed near and at the same time as the proposed Los Vaqueros Reservoir Expansion Project facilities. As summarized on Table 4.1-2, while there are no projects proposed adjacent to project facility sites, there are other projects proposed in the region that might be under construction at the same time as the Los Vaqueros Reservoir Expansion Project facilities. However, like the Los Vaqueros Reservoir Expansion Project, most of these projects will be required to implement site-specific erosion control and water quality control measures as required by state law. These water quality regulations are intended to effectively reduce water quality impacts from each construction site such that significant cumulative effects do not arise. With implementation of proposed mitigation measures to implement appropriate erosion and water quality control during construction (Mitigation Measures 4.5.1a and b, as well as biological mitigation measures 4.6.2a and 4.6.2b), the Los Vaqueros Reservoir Expansion would not make a cumulatively considerable contribution to cumulative water quality effects.

The Los Vaqueros Reservoir Expansion Project would affect topsoil in select areas (i.e., the 160 TAF core borrow area and within the area of pipeline trenching). Other effects such as the potential to destabilize soils are site specific and do not overlap with effects at other sites outside the project area. For this reason, although other projects in the region might remove or cover topsoil with impervious surfaces (primarily large residential developments such as the proposed Cecchini Ranch), the project would not make a cumulatively considerable contribution to cumulative effects on topsoil.

**Mitigation:** None required.