convey and dissipate the volume and energy of peak flows. Therefore, the stage and extent of a flood would not be increased.

4.6.2.6 Impacts from Alternative 3—New Transmission Elk Grove Substation to Tracy Substation

Twenty miles of Alternative 3 alignment occur within the 100-year floodplain. Within these 20 miles, approximately 96 new transmission line structures would be constructed along the new and existing ROW. These activities would disturb approximately 22 acres of the 100-year floodplain temporarily and 10 acres long term.

An additional 25 miles of the Alternative 3 alignment occur within the 500-year floodplain. Within these 25 miles, approximately 225 new structures would be constructed along the new ROW. Resulting impacts to the 500-year floodplain would total approximately 52 acres of temporary disturbance and 24 acres of long-term disturbance.

Floodplain impacts would be similar to those discussed for the Proposed Action. These negligible changes to the 100- and 500-year floodplain would not individually or cumulatively alter the capacity of the floodplain to convey and dissipate the volume and energy of peak flows. Therefore, the stage and extent of a flood would not be increased.

4.6.2.7 Impacts from the No Action Alternative

Without the Proposed Action or action alternatives, no changes to existing facilities or alignment would occur and no new impacts to the active floodplain would be expected. Normal operation and maintenance, repairs, and emergency management of the system would continue as in the past. There are recognized temporary and insignificant impacts from maintaining access and transmission service (for example, vegetation management within the ROW). These impacts would continue as before and be avoided, minimized, or mitigated to the extent possible using Western's established EPMs (Table 3-4).

4.7 GEOLOGY

4.7.1 Affected Environment

This section describes the existing geologic and hydrogeologic conditions and impacts from the implementation of the Proposed Action and alternatives. Geology includes discussions on grading, erosion, mining, and seismicity.

4.7.1.1 Resource Study Area

The focus of the study for geologic constraints and hazards is the transmission line ROW and nearby geologic faults including the Willows, Midland, Stockton, and Midway faults that could potentially affect the transmission lines.

4.7.1.2 Issues of Environmental Concern

Issues of environmental concern for geological resources include erosion, subsidence, landslides, and seismic and related hazards (liquefaction). They are discussed in the following section.

4.7.1.3 Characterization

Regional Setting

The study area lies within the Central Valley of California, a broad depositional basin between the Sierra Nevada Mountains on the east and the Coast Mountain Range on the west. The Central Valley is about 400 miles long by 50 miles wide and covers approximately 20,000 square miles. It contains the Sacramento Valley and the San Joaquin Valley. The surface elevation of the Central Valley lowland rises from slightly below sea level to about 400 feet above sea level at its north and south ends. The valley is unusual for a lowland area because it is a relatively undeformed basin surrounded by highly deformed rocks units. The Central Valley trough has been filled with as much as six vertical miles of sedimentary deposits in the San Joaquin Valley and ten vertical miles of deposits in the Sacramento Valley; these sediments range in age from Jurassic to Holocene. The Sacramento River drains the northern part of the Sacramento Valley, and the San Joaquin River drains the southern part of the San Joaquin Valley.

The geology in the Sacramento Valley relates to three different subbasins within the Sacramento Groundwater Basin: 1) the North American Subbasin; 2) the South American Subbasin; and 3) parts of the Cosumnes Subbasin.

The North American Subbasin lies in the eastern central portion of the Sacramento Groundwater Basin. The Bear River is its northern boundary, the Feather River is its western boundary, and the Sacramento River is its southern boundary. The eastern boundary is a north-south line extending from the Bear River south to Folsom Lake. The eastern boundary represents the approximate edge of the alluvial basin, where little or no groundwater flows into or out of the groundwater basin from the rock of the Sierra Nevada. The eastern portion of the study area is characterized by low, rolling dissected uplands. The western portion is nearly a flat flood basin for the Bear, Feather, Sacramento, and American rivers, and several small east side tributaries. The general direction of drainage is west to southwest at an average grade of about 5 percent (California Department of Water Resources [DWR] 2002, draft Bulletin 118).

The South American Subbasin is bounded on the east by the Sierra Nevada, on the west by the Sacramento River, on the north by the American River, and on the south by the Cosumnes and Mokelumne rivers. These perennial rivers generally create a groundwater divide in the shallow subsurface. There is interaction between groundwater of adjacent subbasins at greater depths (DWR 2002, draft Bulletin 118).

The Cosumnes Subbasin is the area of unconsolidated to semi-consolidated sedimentary deposits bounded on the north and west by the Cosumnes River, on the south by the Mokelumne River, and on the east by consolidated bedrock of the Sierra Nevada Mountains. The Cosumnes Subbasin is bounded on the south and southwest by the Eastern San Joaquin Subbasin and on the north to northwest by the South American Subbasin of the Sacramento Valley Groundwater Basin. The subbasin drains westward through three major rivers, namely the Cosumnes on the north, Dry Creek in the middle, and the Mokelumne River on the south. A large surface water body, the Camanche Reservoir, is located along a portion of the Mokelumne River in the southeast part of the subbasin (DWR 2002, draft Bulletin 118).

The San Joaquin Valley portion of the study area relates to three different subbasins within the San Joaquin Groundwater Basin: 1) the Eastern San Joaquin Subbasin; 2) the Tracy Subbasin; and 3) parts of the Cosumnes Subbasin.

The Eastern San Joaquin Subbasin is the area of unconsolidated to semi-consolidated sedimentary deposits bounded by the Mokelumne River on the north and northwest; San Joaquin River on the west; Stanislaus River on the south; and consolidated bedrock on the east. The Eastern San Joaquin Subbasin is bounded on the south, southwest, and west by the Modesto, Delta-Mendota, and Tracy Subbasins, respectively, and on the northwest and north by the Solano, South American, and Cosumnes Subbasins. The Eastern San Joaquin Subbasin is drained by the San Joaquin River and several of its major tributaries, namely the Stanislaus, and Calaveras, and Mokelumne rivers. The San Joaquin River flows northward into the Sacramento and San Joaquin Delta and discharges into the San Francisco Bay (DWR 2002, draft Bulletin 118).

The Tracy Subbasin is the area of unconsolidated to semi-consolidated sedimentary deposits bounded by the Diablo Range on the west; the Mokelumne and San Joaquin rivers on the north; the San Joaquin River to the east; and the San Joaquin-Stanislaus County line on the south. The Tracy Subbasin is located adjacent to the Eastern San Joaquin Subbasin on the east and the Delta-Mendota Subbasin on the south. All of the above mentioned subbasins are within the larger San Joaquin Valley Groundwater Basin. The Tracy Subbasin also lies to the south of the Sacramento Valley Groundwater Basin, Solano Subbasin. The Tracy Subbasin is drained by the San Joaquin River and one of its major western tributaries, Corral Hollow Creek. The San Joaquin River flows northward into the Sacramento and San Joaquin Delta and discharges into the San Francisco Bay (DWR 2002, draft Bulletin 118).

Geologic Formations in the Study Area

The Proposed Action and alternatives cross three geologic formations (at land surface) between the O'Banion Substation and Tracy Substation. Figure 4-3 shows the geology units that surround the study area. These Quaternary and Tertiary deposits include:

- ***Quaternary Floodbasin (Qb)—***Floodbasin deposits, associated with flood stage on major streams
- ***Quaternary River Deposit (Qr)—***River deposits, associated with river channels, floodplains, and natural levees
- ***Quaternary Continental Deposit (QTc)—*** Continental deposits (older alluvium, fanglomerate, and sedimentary formations)

Floodbasin deposits (Qb) crop out in low-lying areas throughout the Central Valley. They result from flood waters entering low-lying basins and depositing mostly fine silt and clay and some fine sand. Floodbasin deposits grade into river deposits, rocks, deposits of Tertiary and Quaternary age, and lacustrine and marsh deposits. As with most deposits of Quaternary age in the valley, contact with underlying deposits is difficult to determine. The DWR stated that the floodbasin deposits in the Sacramento Valley consist of as much as 160 feet of fine-grained sediments in the area west and south of Sacramento. In the San Joaquin Valley, the deposits were estimated to be as much as 100 feet thick (USGS, Prof Paper 1401-C, 1986).

River deposits (Qr) crop out along the major rivers and streams of the Central Valley and include channel and floodplain deposits. River deposits are still accumulating, except where human activity intervenes. Channel deposits, which consist chiefly of sand and gravel, range in width from a few feet to nearly 1,000 feet. Floodplain deposits generally are finer-grained than channel deposits and consist chiefly of sand and silt. They range in width from a few hundred feet to more than three miles. Because soil development and topography are the criteria for mapping river deposits, subsurface contact with underlying deposits is poorly defined. River deposits in the Sacramento area have been described as predominantly coarse-grained at relatively shallow depths that appear to be hydraulically continuous with the present stream channels, floodplains, and natural levees. The DWR believes that the river deposits are a maximum of about 115 feet thick and that they are the most permeable deposits in the Sacramento Valley (USGS, Prof Paper 1401-C, 1986).

Continental deposits (QTc) are largely of Holocene age; along their outer margins, however, some may be Pleistocene age. The deposits crop out chiefly along the major rivers and streams of the valley, as well as in other low-lying areas, and include river deposits, floodbasin deposits, and sand dunes, all of Holocene age. In places, they may include such deposits as the Modesto Formation of Pleistocene age (USGS, Prof Paper 1401-C, 1986).

Figure 4-3 presents geological deposits in the vicinity of the study area. Segments of transmission lines in relation to local geology are described below.

River deposits pose the greatest concern for building or accessing transmission lines. The deposits consist of sand and gravel, usually unconsolidated, are typically water bearing, and are poor for compaction and drilling. River deposits along the ROW are approximately perpendicular to the route because they follow the rivers west from the Sierra Nevada Mountains. Segments A and A_1 cross about four miles of river deposits along the Feather River from MP 10.0 to 14.0. Segment C crosses river deposits from MP 4.0 to 10.0, and Segment D crosses river deposits from MP 0.0 to 3.0. Segments E and E_1 cross river deposits at the Cosumnes River from MP 2.0 to 4.0 and MP 5.0 to 6.0 at Dry Creek from MP 10.0 to 11.0, and the Mokelumne River from MP 12.0 to 13.0.

The continental deposits are the most geologically stable and are most prevalent along the study area in Sacramento County. Continental deposits are present in Segments A and A_1 from MP 0.0 to 10.0 and MP 14.0 to 22.0 and all of Segments B, F, G, and H.

Continental deposits are again present in Segment D from MP 3.0 to 14.0 and Segment E from MP 0.0 to 2.0, MP 4.0 to 5.0, MP 6.0 to 10.0, MP 11.0 to 12.0, MP 13.0 to 18.0 and MP 44.0 to 46.0. Floodbasin deposits are more suitable for construction than river deposits, but less suitable than continental deposits. In San Joaquin County, floodbasin deposits are the primary material along the proposed routes. Floodbasin deposits are present in Segment E from MP 18.0 to 44.0.

Mining

Several sand and gravel mines are located in the vicinity of the study area including one along Segment D between MP 4.2 and 5.5. Transmission lines can be placed in locations not interfering with these mining operations.

Faults

Earthquakes occur along fault zones. A fault zone is a break in the continuity of a rock formation caused by a shifting or dislodging of the earth's crust. Figure 4-3 shows faults near the study area. The nearest historically active fault is the Concord Fault, approximately 50 miles west of the study area. Displacement on the Dunnigan Fault, about 20 miles west of Segments A, A_1, and C, has occurred within Holocene time (within the last 10,000 years), and the Vernalis Fault, near Tracy, has had activity in the Quaternary Period (within 1.6 million years). The nearest faults to the ROW have not been active within Quaternary times. These include the Willows Fault, the Stockton Fault, and the Midland Fault. The Willows Fault roughly parallels the ROW from the beginning of Segment A and A_1 south to about Segment D MP 7.0 at the Hedge Substation. The fault lies within 1 to 5 miles of the study area and crosses the study area at the O'Banion Substation, Segment A MP 4.0, the Elverta Substation, and coincides with the study area between Segment D MP 2.0 to the Hedge Substation. The Stockton Fault is as close as four miles southeast of the study area between Segment E MP 30.0 and the Tracy Substation. The Midland Fault is as close as 4 miles west of the study area between Segment D MP 12.0 and the Tracy Substation.

Seismicity

A Seismic Zone classification is used by the Uniform Building Code (UBC) to define the magnitude of protection required for building design to withstand earthquake risk in the area or from adjacent areas. UBC Seismic Zones range from 1 to 4 (with Zone 4 having the highest risk) and are based on a 10-percent probability of specific peak ground acceleration (PGA) values being exceeded within 50 years. The entire study area is within UBC Zone 3. All of California is seismically active, with numerous historic earthquakes and seismic activity recorded by instruments daily. Seismic Zone 3 could have earthquakes with a Modified Mercalli Intensity (MMI) rating of VIII or higher. The MMI scale rates earthquakes by their effect on people, structures, and objects. Major structural damage would typically occur from an earthquake with an intensity of VIII or higher. Intensity VIII is generally equated with an average peak acceleration of 20 to 30 centimeters per second (cm/sec). This intensity typically results in slight damage to specially designed structures; considerable damage to ordinary, substantial buildings, with partial collapse; and great damage to poorly built structures. This intensity could also result in falling columns, monuments, and walls (Bolt 1988). Secondary hazards of earthquakes include rapid ground settlement (subsidence), landslides and rockfalls, and liquefaction. These hazards are discussed below.

Subsidence

Land subsidence occurs when the ground surface decreases in elevation. It can be caused by various natural phenomena such as tectonic movement, consolidation, hydrocompaction, or rapid sedimentation. Subsidence can also result from a variety of human activities, including withdrawing water or petroleum from the subsurface. The numerous fine-grained (clayey) lenses in Central Valley deposits are conducive to subsidence. The southern San Joaquin Valley (south of Tracy Substation) has the largest volume of land subsidence in the world (from groundwater withdrawal), and many areas of the Central Valley are vulnerable to this phenomenon. The other important cause of subsidence in the Central Valley is oxidation and compaction of peat soils caused by draining soils nears the confluence of the San Joaquin and Sacramento Rivers. The southern portion of Segment E, from approximately Stockton to Tracy, runs along the edge of an area of subsidence caused by compaction of peat according to a 1952 Field survey (Williamson 1989). Subsidence is typically a slow process, unless induced by seismic activity. Its potential effects on structures might not be evident for years or decades.

Landslides and Rockfalls

Landslides, rockfalls, mudslides, and debris avalanches refer to rock or debris descending a slope due to gravity. Slopes within the study area are typically shallow or nonexistent, making landslides unlikely. Construction in areas with steep slopes should be avoided whenever possible. These limited areas may include the banks of some rivers, levees, or canals.

Liquefaction

Liquefaction occurs when saturated soils lose strength and cohesion when subjected to dynamic forces, such as shaking during an earthquake. Liquefaction can also occur in unsaturated soils with low cohesion, such as sand. Liquefaction and related phenomena have caused tremendous amount of damage during historical earthquakes when water pressure between soil particles can increase until the soil cohesion is lost, along with the support that it normally supplies to building foundations. Liquefaction occurs more frequently in areas where groundwater is very shallow, such as in river deposits near water bodies. Quaternary River Deposits (Segments A, A_1, C, D, E, and E_1) may be prone to liquefaction.

4.7.2 Environmental Consequences

4.7.2.1 Standards of Significance

Significant geologic impacts would result if structures were to fail or create hazards to adjacent property due to slope instability, effects of earthquake, or adverse soil conditions (such as compressible, expansive, or corrosive soils).

4.7.2.2 Environmental Protection Measures

EPMs for geologic resources from Table 3-4 include the following:

- A California registered Professional Geotechnical Engineer would evaluate the potential for geotechnical hazards and unstable slopes on the centerline route and areas of new road construction or widening on slopes with over 15 percent gradient.
- Geological hazards would be evaluated during final design specification for each structure location and road construction area. Options would include avoidance of a poor site by selection of a site with stable conditions, or correction of the unstable slope conditions.

4.7.2.3 Impacts from the Proposed Action, Alternative 1, Alternative 2, Alternative 3, and No Action

No noteworthy geological features were identified to distinguish among the Proposed Action and alternatives. Therefore, the discussion on geology applies to all alternatives. Potential impacts to the Proposed Action and alternatives would be similar, although the specific locations might vary. The route for the Proposed Action and Alternatives 1 and 2 would cross a fault zone that has not been active within the past 1.6 million years; therefore, this is not considered to have more seismic impact than Alternative 3.

Any steep or unstable slopes near the Proposed Action or alternatives ROW would be avoided or minimized with standard construction practices described above. Alternative 3 would cross fewer miles of river deposits than the Proposed Action or other alternatives; however, it would cross 26 miles of floodbasin deposits that could also succumb to earthquake forces, such as liquefaction, more readily than the continental deposits that predominate in the Proposed Action, Alternative 1, and Alternative 2. Geological hazards would be evaluated during final design specification for each structure location and road construction area and standard design practices would be used.

Sand and gravel mining operations (Segment D) would be avoided, and would not be impacted by the Proposed Action or alternatives. No significant geologic impacts are noted for the Proposed Action or alternatives.

4.8 HEALTH AND SAFETY

4.8.1 Affected Environment

This section describes the health and safety issues associated with the Proposed Action and alternatives.