4.2 GEOLOGIC RESOURCES (GEOLOGY, TOPOGRAPHY, SOILS/SEDIMENTATION, SEISMICITY)

4.2.1 Regulatory Setting

See sections 3.3.1, 3.3.2, and 3.3.3 for a description of the regulatory setting for geologic resources.

4.2.2 Existing Conditions

Information contained within this section for the baseline analysis of geology, soils, and seismicity has been derived from a number of previous studies and reports including the following: a preliminary environmental analysis by BioSystems, Inc. (1995) titled *Upper Guadalupe River Interim Feasibility Report, Environmental Working Paper, Final Report*; the Corps compilation of the *Upper Guadalupe River Interim Feasibility Report* (COE 1993), which included a subsurface investigation (62 electric cone–penetrometer test probings and 11 geotechnical borings) within Reaches 7–12, Canoas Creek, and Ross Creek; an Engineering-Science, Inc. investigation of geotechnical conditions along the project alignment for the *Draft EIR/EIS for the Guadalupe River Flood Control Project* (Parsons Engineering Science 1997); and a Philip Williams & Associates, Ltd. study of geotechnical conditions for the *Sediment Assessment Study of the Upper Guadalupe River* (COE 1993).

Topography

The project study area lies within the Guadalupe River drainage basin encompassing a total of approximately 170 square miles. The upper Guadalupe River drainage area (Guadalupe River upstream of Los Gatos Creek) comprises approximately 95 square miles. Elevations within the watershed range from 0 at the Guadalupe River-Alviso Slough at the southern tip of San Francisco Bay to over 3,790 feet NGVD (National Geodetic Vertical Datum of 1929) at Loma Prieta Peak in the Santa Cruz Mountains. Flowing north in a slight meander across the gentle gradient of the Santa Clara Valley, the Guadalupe River is within a watershed that is bounded on the south and southwest by the Santa Cruz Mountains, on the west by the drainage basins for San Tomas and Saratoga Creeks, on the east by the Coyote Creek Basin, and on the north by San Francisco Bay. Along the project study area, there is less than a 100-foot change in elevation. River bank elevations range from elevation 107 feet NGVD at Willow Street to elevation 180 feet at the Highway 85 freeway bridge crossing.

Regional Geology

The flood control project is located within the Santa Clara Valley, a structural depression referred to as the San Jose Plain. Geologic materials in the valley may be classified as older consolidated rock exposed in the surrounding mountains and younger unconsolidated fill sediments in the valley depression. The depression is filled with thick sequences of Plio-Pleistocene and Holocene age, unconsolidated alluvial (water-borne) fill. The alluvial fill ranges up to 1,500 feet thick in some places and lies over Jurassic–Cretaceous to Tertiary age bedrock of the Franciscan Formation. The fill material is composed of sand, gravel, silt, and clay that washed into the Santa Clara Valley from the bordering mountains. Deposition has been influenced by sedimentation rates and fluctuations in sea level due to glaciation.

The vertical and lateral distribution of rock and sediments in the valley has been modified by faulting and associated folding during the Cenozoic time period. The valley floor consists of an interbedded sequence of discontinuous, heterogeneous fluvial (transported by river or stream) deposits and continuous, relatively stratified basin and homogeneous estuarine clays. The project study area is located in the upper portion of the alluvial plain where the Guadalupe River downcut into the older Pleistocene Age alluvial fan deposits and then filled in with Holocene age alluvium. Alluvial deposition still occurs during flood stages of the rivers.

Site Geology and Soils

As described above, the project area is underlain by up to several hundred feet of alluvial deposits that overlie Franciscan bedrock. In general, the alluvial deposits have been characterized as unconsolidated well-graded, interbedded fine sands and silts with some gravel. Older Guadalupe River channel deposits vary locally and are composed of coarse grained or poorly graded sediments that were deposited by the ancestral Guadalupe River. These deposits are sometimes incised by the current river channel. The project study area reach of Ross Creek has been excavated and is channelized across natural levee deposits of the Guadalupe River. The surficial geology of the project study area is depicted in Figure 4.2-1. The geology surrounding Reach 7 is mapped as a Quaternary fluvial unit (Qyfl), the area along Reaches 8–12 is mapped as a Quaternary younger alluvium unit. Other surficial geologic units mapped in the study region include Quaternary bay mud (Qb), Quaternary older alluvium (Qof), and Cretaceous Franciscan Formation (Kf). Bedrock elevation is variable across the project area, ranging from -800 feet NGVD below Willow Street to an outcropping adjacent to the river at Oak Hill.

The surficial soils within the project study area have been mapped by the U.S. Department of Agriculture, Soil Conservation Service (SCS 1968). As depicted in Figure 4.2-2, these soils are composed of three soil types or associations: the Yolo, which includes all of the soils in Reaches 7 through 9 and portions of Reaches 10 through 12; the Clear Lake-Campbell, including portions of reaches 10 and 11; and the Sunnyvale-Castro-Clear Lake, which includes portions of Reach 12. These classifications are generally applicable to the upper 5 feet of the surface soils. The Yolo Association consists of silty-loams over clayey loam soils that are well drained with high percolation rates, low runoff rates, low shrink-swell capacity, and low erosion potential. The Clear Lake–Campbell Association are silty clays over clayey loam soils and the Sunnyvale–Castro–Clear Lake Association are calcareous silty-clays over calcareous clays. The latter two associations are poorly drained soils with low percolation rates, high runoff rates, moderate to high shrink-swell capacity, and moderate to low erosion potential.

The cone-penetrometer test probings conducted by the Corps indicated that the upper 30 feet of soil consists of interbedded silty clays, sandy clays, silts, clayey sand, and silty sands of variable thicknesses. The testing revealed a general trend of silty to sandy clays and clayey silts along Reaches 7 and 8 and sandier soils, with interbeds of silts and silty to sandy clay along Reaches 9–12. The sediment assessment prepared by Philip Williams & Associates (COE 1993) indicates that the study area is a stratified section of non-cohesive sand and gravels with cohesive silts and clays. Water erosion occurs more readily in the sand and gravels such that the river begins to undercut the overlying clay and silt beds. This condition makes the river susceptible to future bank erosion and channel widening.

Subsidence

The Santa Clara Valley has historically experienced significant land subsidence due to excessive pumping of underlying confined groundwater aquifers. This pumping caused increased vertical loads to compact the confining silt and clay aquitards, resulting in land subsidence throughout the valley. Within the feasibility study area vicinity, the maximum land subsidence between 1934 and 1968 was over 8 feet in an area southeast of downtown San Jose. The total maximum subsidence at this location is estimated to be just under 13 feet (personal communication Tom Iwamura 1997). Between 1934–1967, subsidence

Figure 4.2-1 Geologic Map

Figure 4.2-2 Soil Associations Located in the Area ranged from 0.25 feet near Reach 6 (north of the feasibility study area and part of the SCVWD separate but related flood control protection project) to 3.7 feet near Reach 12. Importing State water through the South Bay Aqueduct in 1968 greatly reduced the demand for pumped groundwater, effectively controlling the subsidence due to overpumping of groundwater in the region. In addition, the percolation ponds constructed along the Guadalupe River, in and upstream of Reach 12 and elsewhere in the Santa Clara Valley, provide substantial groundwater recharge. Further subsidence due to groundwater withdrawal is not likely as long as adequate supplies and recharge capability remain available. However, it has been estimated (Atwater et al. 1977) that minor tectonic subsidence in the area is occurring at a rate of 0.3 to 0.5 mm per year. This subsidence would have little to no effect on the project over its projected 100-year life.

Seismicity

The tectonic setting of the San Francisco Bay area is characterized by three primary structural blocks, roughly separated by the active San Andreas and Hayward faults (Figure 4.2-3). These two fault zones are active members of the San Andreas Fault system that forms the boundary between the North American crustal plate and the Pacific Ocean plate. The Hayward and Calaveras fault zones branch off the San Andreas fault south of the project area. The Hayward fault extends north of the project area along the base of the Berkeley Hills to San Pablo Bay or farther. The San Andreas fault separates the San Francisco-Marin block on the east from the Point Reyes-Montara block on the west. A third major fault in this region is the Calaveras Fault, which lies east of the Guadalupe River and joins the Hayward Fault zone southeast of the project area. All of these faults are oriented in a general northwest–southeast trending direction, evidence of their relationship to the San Andreas fault. Historically, very damaging earthquakes have occurred on the faults associated with the San Andreas Fault system.

Additionally, eight less significant fault zones run through or along the margins of the San Jose Plain in this region: the Crosely-Evergreen, Sargent, Cascade, Shannon, Santa Clara, Silver Creek, Coyote Creek-Piercy, and Berrocal faults. Table 4.2-1 summarizes the characteristics of these faults.

Earthquakes of various size in the general region of the project are a major threat to the soil stability within the project study area and vicinity. Causing health and safety hazards and damage to buildings and roads, other potential effects of earthquakes can be liquefaction or ground failure in surface materials. Further potential hazards exist from the erosion and loss of river bank stability. The potential for a given material to be affected depends on its physical properties and its proximity to the fault trace. Unconsolidated, saturated fine sands and silts as well as unconsolidated moist to wet clays experience the greatest soil movement and ground shaking acceleration. Saturated fine sands and silts are also susceptible to liquefaction. Steeper slopes would be more prone to ground failure from liquefaction.

Ground accelerations in the project area could reach a mean of up to 0.34g from the San Andreas and Calaveras fault zones. Activity on the Hayward and Crosely-Evergreen fault zones could result in a mean ground acceleration rate of 0.65g in the project area. A more conservative estimate of ground acceleration, the mean-plus-one standard deviation, indicates that these faults could cause a ground acceleration rate of 1.00g in the project area. Probable active faults that lie under or close to the project area could cause even greater ground accelerations at the site.

Within the project study area, the seismic stability relative to the potential for liquefaction and landslides has been estimated. These estimates show a moderate to high potential for liquefaction throughout the project study area. They assume a major seismic event occurring during a wet season when the water

Figure 4.2-3 Regional Active and Potentially Active Faults table is high and the risk of liquefaction is substantially increased. Under dry conditions, with the groundwater table at a minimum of 20 feet below the surface, a majority of the sediments and surface deposits along the Guadalupe River have a low to moderate potential for liquefaction and ground failure in the event of a large earthquake.

Table 4.2-1. Characteristics of Faults in the Guadalupe River Region

Fault Zone	*Distance from Project*	*Maximum Credible Magnitude*	*Creep Rate (mm/yr)*	*Potential Ground Acceleration*	*Activity Classification*
San Andreas	9 mi	8.3	12.2	0.5g (gravity)	Active
Hayward	7 mi	7.0	6.0	0.5g	Active
Calaveras	10 mi	7.3	5.3	0.7g	Active
Evergreen-Crosely	6 mi	6.9	--	0.6g	Active
Sargent	9 mi	6.5	--	0.3g	Active
Shannon	2.5 mi	6.7	--	0.5g	Probably Active
Cascade	1 mi	6.6	--	0.7g	Probably Active
Santa Clara	0 mi	6.8	--	0.9g	Probably Active
Silver Creek	2.5 mi	6.2	--	--	Potentially Active
Coyote Creek-Piercy	0 mi	--	--	--	Potentially Active
Berrocal	4 mi	6.7	--	--	Potentially Active

Notes: Magnitude ratings are based on the Richter Scale.
Portions of the Hayward Fault are not active.
Hayward Fault creep rates are from Alameda County.
The Shannon and Piercy fault zones extend under the project area.
Active = Holocene activity (less than or equal to 11,000 years offset).
Probably Active = Evidence of late Quaternary activity.
Potentially Active = Quaternary activity (less than or equal to 3 millions years offset).
mm/yr = millimeters per year

Source: Parsons Engineering Science 1997; COE 1993.

4.2.3 Environmental Effects

Impact Significance Criteria

Geologic and seismic impacts are considered significant if, due to project construction or operation, people or property are exposed to geologic hazards. These hazards would include the following:

- Earthquake-induced ground motion resulting in substantial damage to project structures, and endangering human life;

- Near-surface geologic conditions are sufficiently unstable or otherwise susceptible to failure such that soils and geologic engineering techniques do not reduce geologic hazards to a level of insignificance.

Channel Widening Plan

Impacts to the geologic environment from the proposed project are associated primarily with project construction activities (e.g., sedimentation). Geologic impacts associated with post-construction flood protection would result from regional (e.g., seismic) and local (e.g., ground failure) geologic hazards. Construction impacts would predominantly be associated with increased erosion due to the extensive earthwork activity that would be required to construct the various flood control improvements along the river corridor. In particular, the channel widening proposed under this alternative would require excavation of major volumes of soil. The channel widening proposed would require earthwork along the existing banks, exposing channel slopes to wind and water erosion, which could significantly increase downstream sediment loads. Impacts from sedimentation would be mitigated to insignificance. Cut slopes would be hydroseeded and mitigation plantings would be established on either flat bench areas or on undisturbed areas currently lacking riparian forest, with the exception of visual mitigation plantings and a few habitat mitigation plantings. The threat of increased sedimentation would remain during the short- and intermediate-term until the erosion control hydroseeding and plantings on channel benches and undisturbed areas become stabilized.

Other construction impacts would be related to reinforcing excavation areas. Improperly placed or designed reinforcement could allow for lateral movement of the supported soils and settlement of the adjacent ground surface. Reinforcing would be particularly necessary where slopes composed of sand and silts are saturated. Additionally, the driving of piles for the shoring system could cause excessive ground vibrations. This can lead to settlement of the ground surface where loose sandy soils are present due to densification caused by the vibrations. Installation of adequate reinforcement necessary for proper construction can be accomplished using standard engineering construction techniques. Impacts would be insignificant.

Operational impacts could result during seismic events that destabilize excavated cut banks, and could result in ground failure of soils adjacent to and underlying structures. The extent of structural failure would largely depend upon the construction techniques employed. Slope instability along the flood control channel would be highest for those channels with the steepest slopes. The unconsolidated alluvial deposits that make up the project study area generally have a maximum angle of stability of 33 percent. Oversteepening and/or saturation of these soils resulting from groundwater recharge or flooding could cause slope instability and trigger ground failure. This impact would be less than significant by providing appropriate internal slope reinforcement.

Another hazard would be the threat of slope failure from a local or regional seismic event. Earthquakes can produce strong ground shaking that, in saturated soils, could also result in liquefaction, lateral spreading, ground cracking, and structural damage. In oversteepened channel slopes, seismic activity could trigger landslides. Channel banks with slopes greater than 2:1 (horizontal:vertical) would be the most susceptible to failure during an earthquake. All engineered structures, however, would be designed in accordance with required Uniform Building Code specifications for Seismic Zone IV. These specifications would mitigate impacts to insignificant levels.

Bypass Channel Plan

The construction-related and operational impacts of this alternative would be similar to those identified for the Channel Widening Plan. However, due to the larger size of the project (i.e., greater area of ground disturbance, the impacts identified would be slightly greater for this project. Impacts would be mitigated to insignificance with measures discussed for the Channel Widening Plan.

No-Action Alternative

The construction-related impacts identified above would not occur if the No-Action Alternative were chosen. Geologic hazards affecting the existing channel and flood control structures would not be increased or reduced.

4.2.4 Mitigation Measures

Mitigations for the impacts resulting from the Channel Widening and Bypass Channel Plans are detailed below.

Channel Widening Plan

The following is a required measure that has been incorporated as an element of the project description to ensure conformance with standards of the NPDES permitting program required by the RWQCB. The project component would address excessive sedimentation of the river downstream of project construction activities.

1. A Storm Water Pollution Prevention Plan (SWPPP) shall be prepared and executed that contains the following:

    a. Excavated soils shall be removed from the project area for use off site immediately following excavation. Where immediate removal is infeasible, silt fences shall be placed around any soil piles that need to remain on the project site. Other exposed soils shall be stabilized using standard techniques typically employed in such projects (e.g., revegetation, jute netting, staked hay bales, water bars, etc.).

    b. Major project construction earthwork shall occur during the summer and fall months to avoid the rainy season (November–April).

2. Cut slopes shall be reinforced internally to provide stability. Gabions shall be used to protect against erosion at locations with high water flood velocities. Cribwall construction shall be used where cut slopes are nearly vertical.

Bypass Channel Plan

The required project description components discussed for the Channel Widening Plan would apply to the Bypass Channel Plan.

4.2.5 Unavoidable Significant Adverse Impacts

There would be no unavoidable significant impacts associated with geologic hazards with the project components described above.