4.6 GEOLOGY AND SOILS

4.6.1 Introduction

This section of the DEIR discusses the geologic resources on the Project Site and presents an analysis of the impacts and mitigation measures for the potential soil disturbance, slope stability, and seismic hazards associated with the Proposed Project. This section includes information from the geologic investigations performed by Golder Associates, *Reclamation Slope Stability Evaluation*, January 2010; Benchmark Resources, *Carmelita Project Reclamation Plan*, June 2010, Benchmark Resources, *Carmelita Project Geology and Soils Environmental Assessment*, July 2010; and URS, *Carmelita Project EIR Technical Report Review*, December 2010. The three technical reports are included as Appendix H-1 and the Technical Report Review is included as Appendix H-2 of this DEIR. The County and its EIR preparer conducted a peer review of these assessments and independently verified the analyses and conclusions. In May 2011, the Applicant submitted a revision to their project description (see Chapter 1.0, Introduction and Chapter 3.0, Project Description) that incorporated setbacks and plant relocation into the design. The revised project description also amended the finish slope angle to 2:1 (horizontal to vertical). The revised project description has been incorporated into this analysis.

4.6.2 Environmental Setting

Of the 11 geomorphic provinces in California, Fresno County is primarily located in the Great Valley and Sierra Nevada Geomorphic Provinces. The Great Valley Province is a broad alluvial plain, extending from the northern part of the Sacramento Valley to the southern part of the San Joaquin Valley. This province is approximately 50 miles wide and 400 miles in length. The County is located within the San Joaquin Valley section of this Province. The western portion of the County extends through this province to the eastern section of the Ranges Geomorphic Province (see Appendix H-1).

The Great Valley Province is a trough in which sedimentation has been occurring since the Jurassic Period (about 208 to 144 million years ago). However, most of the sedimentation in the Great Valley Province occurred in the Cenozoic Era (beginning 65 million years ago). Sediments in the San Joaquin Valley are generally of two types. The upper sediments range from the recent Holocene Epoch to the Oligocene Epoch (37 to 24 million years ago). The lower sediments are composed of marine rocks of the Pliocene Epoch (5.3 to 1.6 million years ago) to the Eocene Epoch (58 to 37 million years ago) (see Appendix H-1). These sediments average approximately 2,400 feet in thickness in the Great Valley Province. However, the deepest deposits occurring in the San Joaquin Valley can be more than 9,000 feet thick in portions of the Tulare Basin, which is partly located in Fresno County (see Appendix H-1).

The Sierra Nevada Geomorphic Province parallels the western side of the Great Valley Geomorphic Province and is a tilted fault block formed by historical tectonic plate action. This province is also approximately 400 miles long. The eastern portion of the County extends into this province.

The eastern side of the Sierra Nevada Province is characterized by high, rugged scarp, while the western side tends to have gentler slopes, averaging about two degrees. Deep river canyons along the western slope cut this province. Many of these rivers have formed large alluvial fans as they leave the mountainous area of the Sierra Nevada Province and enter the flat, level terrain of the Great Valley Province. The most notable in the Fresno County region are the alluvial fans of the San Joaquin River and the Kings River.

The upper granites of the Sierra Nevada Mountains have been scoured by glacial activity. Most of the granitic rocks of this province are Mesozoic Era (approximately 248 to 65 million years ago). These granitic rocks are partially capped by Cenozoic Era, Tertiary Period (between 65 to 1.6 million years ago) volcanic material (see Appendix H-1).

4.6.2.1 Geologic Setting

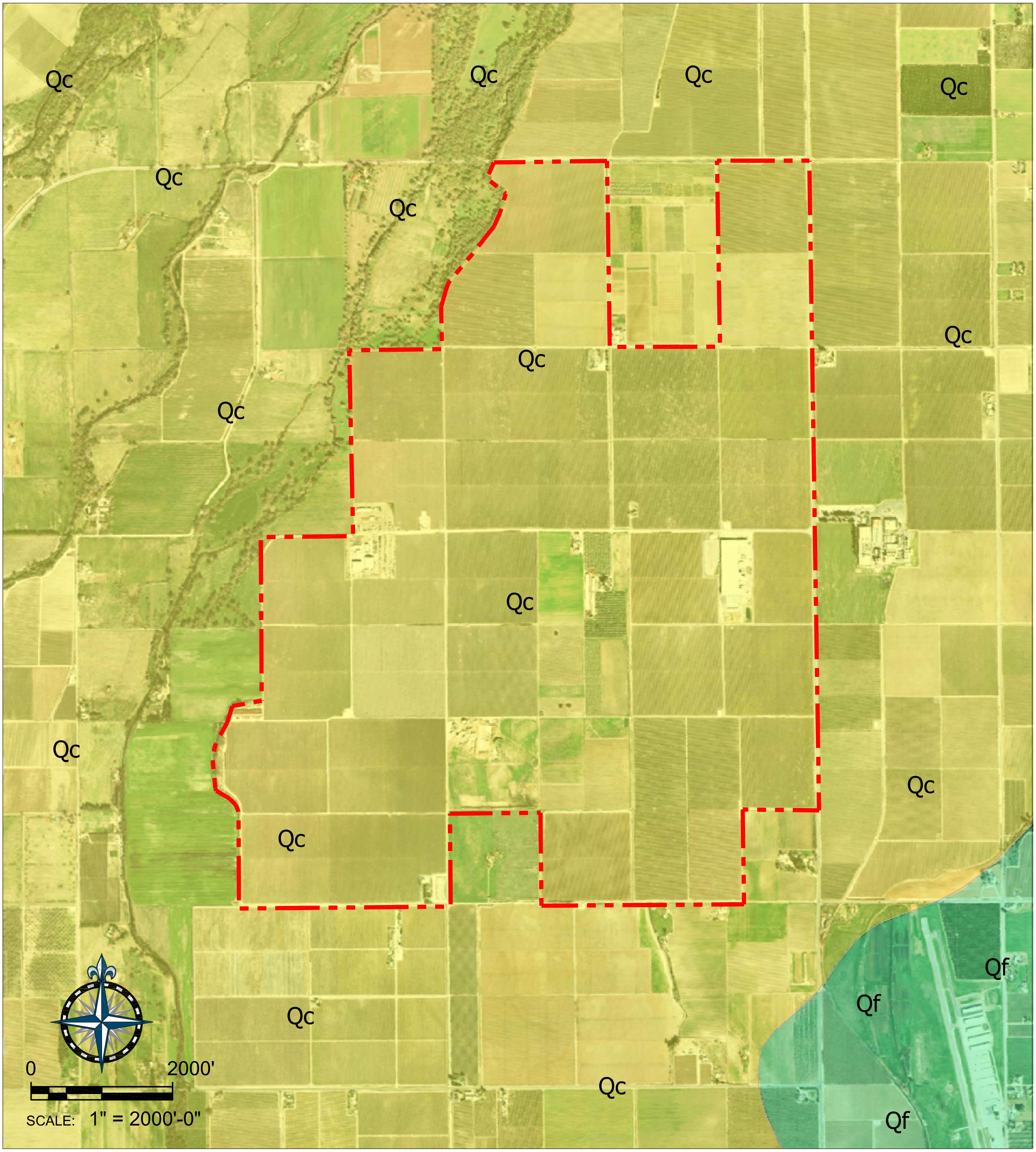
The Project Site is located approximately 2 miles southeast of the Kings River and encompasses an area of about 2.4 square miles at the base of the western side of the Sierra Nevada Mountain Range (see Figure 4.6-1, Regional Geology Map). The Sierra Nevada Mountain Range is a northwest/southeast-trending structural block that slopes gently to the west and dips steeply on its eastern flanks. Intrusive igneous rocks (i.e. granite, tonalite, monzonite, and granodiorite) are the dominant rock types that compose the range.

On the western margin of the Sierra Nevada foothills, the rock types differ. Extending east of the field area from Bear Mountain, Dalton Mountain, and Bald Mountain, northeastward through Hog Mountain to Owens Mountain, the rock types are metamorphic in origin. The mountains mentioned consist mainly of serpentine, metagabbro, and hornfels, which are metavolcanic and metasedimentary in origin (see Figure 4.6-1).

In the geologic past, the deposition environment in and around the field area was influenced by periods of glacial and interglacial episodes that occurred during the span of the Pleistocene Epoch (approximately 1.8 million years ago to 11,550 years ago). During periods of glaciation, high cycles of aggradation occurred, and interglacial periods produced cycles of erosion or low aggradation. Large accumulations of material formed a broad alluvial fan that opened westward and merged with other alluvial fans to form a part of the western portion of the Great Valley Sequence. The Great Valley Sequence includes stream channel deposits, fan deposits, and basin deposits.

The Project Site is located in the eastern portion of Fresno County. This area is a general transition zone between the Great Valley Geologic Province and the Sierra Nevada Geologic Province (refer to Figure 4.6-1).

The Kings River flows from northeast to southwest, in relation to the location of the Project Site. Most of the Kings River area near the Project Site is part of a large alluvial fan. The majority of the material in this alluvial fan was the result of Pleistocene Epoch glaciation cycling (1.6 million to 11,000 years ago) in the Sierra Nevada Mountain range. As a result, most of the rock materials in the fan are composed of granitic materials, although finer sediments composed of various amounts of sands, silts, and clays are present in the alluvium.



SOURCE: Department of Conservation, Division of Mines and Geology (1991)

Source: Benchmark Resources, 12/2010.

Regional Geology Map

Carmelita Mine and Reclamation Project
County of Fresno, California

Figure 4.6-1

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The Kings River alluvial fan has a tear-drop shape and starts in the Avocado Lake and Holland Creek area, north of the Project Site. The alluvial fan extends to an arc of the current Kings River, near Vino and Frantz Avenues. The fan is approximately 13 miles long and about 6 miles in breadth at its widest section. The City of Sanger, the Town of Centerville, Newmark Avenue, Flume Avenue, and Trimmer Springs Road border the alluvial fan on the western side of the fan. Frankwood Avenue, Campbell Mountain, Jesse Morrow Mountain and Tivy Valley border the eastern portion of the fan.

Asbestos has been identified in 20 states, including California. For California, the main asbestos mineral of concern is serpentine, an apple-green to black rock often with light and dark colored areas, but tremolite- and actinolite-bearing rocks have also been identified in several counties. Serpentine rocks have been found in 44 of the 58 California counties, extending from the southern to the northern Coastal Ranges, the Klamath Mountains, and in the Sierra Nevada foothills (see Appendix H-1). Of recent concern have been deposits of serpentine, tremolite, and actinolite rock in Plumas, El Dorado, and Sacramento counties. Not all serpentine rocks contain asbestos. However, because serpentine rocks often contain at least some asbestos, natural deposits of these rocks are of concern to public health agencies.

Possible asbestos-bearing rocks have been found in most counties along the coast and inland from Los Angeles County to the Oregon border, including Fresno County. The only area identified by the California Geological Survey (see Appendix H-1) as containing possible asbestos materials in Fresno County is a deposit north of the Pine Flat Dam in the Granite Ridge area. This location is approximately 13 miles northeast of the Project site. It is unlikely the Project Site contains asbestos bearing rocks.

4.6.2.2 Seismic and Other Hazards

Geologic hazards include earthquake-induced hazards (e.g., ground shaking, surface fault ruptures, and soil liquefaction), slope instability, ground subsidence, soil erosion, and volcanic events.

Seismicity

The Project Site is in a relatively earthquake-free zone. The area has not been identified as being within an Alquist-Priolo Earthquake Fault Zone. The Uniform Building Code (UBC) has designated this area as a Seismic Zone 3. Zone 3 areas can experience major damage from an earthquake. Due to the number of faults throughout California, almost all of the state falls within a Seismic Zone 3 or 4.

The only identified significant fault near the Project Site is the Clovis Fault. This fault is approximately 5 to 6 miles east of the City of Clovis. The Clovis Fault is believed to have been active during the Quaternary Period (past 1.6 million years), but there is no historical evidence of recent age activity in this fault. Consequently, this fault is classified as “potentially active.” It is believed that this fault runs along the foothills of the Sierra Nevada Mountains from an area near the San Joaquin River to north of the Town of Centerville.

Surface Fault Rupture and Ground Shaking

In 1973, five counties (Fresno, Kings, Madera, Mariposa, and Tulare) undertook the preparation of the *Five County Seismic Safety Element* to assess seismic hazards in the region. This study concluded that if a Maximum Credible Earthquake (MCE) occurred along the San Andreas Fault, "relatively low levels of shaking should be expected in the eastern and central parts of the valley." Additionally, this study concluded that a major seismic event on the Owens Valley Fault would have a low level surface amplification on the western side of the Sierra Nevada Mountains due to granitic rock structure of this mountain range (see Appendix H-1).

The Clovis Fault is located to the north of the Project Site. Because this fault is considered "potentially active", surface faulting is considered possible along the fault line. However, since the fault does not pass through the Project Site and historical records of the fault's activity are unknown, the risk of surface faulting and strong ground shaking at the Project Site is considered to be minimal.

Liquefaction

Liquefaction is a phenomenon in which 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. Ground failure resulting from liquefaction can include sand boils, ground settlement, ground cracking, lateral spreading, slope toe failure, and ground warping.

Geologic conditions at the Project Site consisting of a mix of alluvial sources, gravels and cobbles, are not prone to liquefaction. This is principally due to the lack of a known seismically active area as well as the absence of unconsolidated, saturated, clay-free sands and silts at the Project Site. Additionally, areas of liquefaction have not been identified on the Project Site.

Tsunami and Seiche

A tsunami is an ocean water wave or series of waves generated by a sudden displacement of the ocean surface or other deep body of water. Given the great distance of the Project Site to the nearest ocean, the Pacific Ocean, the risk of a tsunami affecting the Project Site is remote.

A seiche is a periodic oscillation or "sloshing" of water in an enclosed basin (e.g., lake or reservoir) caused by an earthquake. The period of oscillation is dependent upon the size and configuration of the water body and may range from minutes to hours. As a result, seiches have the potential to damage dams, levees, or shoreline structures such as residential dwellings, boat docks, or recreational facilities.

The nearest large enclosed water body to the Project Site is Avocado Lake, approximately 7 miles northeast of the Project Site. However, this lake is a small water body and would not be subject to strong oscillations during an earthquake event. Therefore, the risk of seiches affecting the Project Site is insignificant.

Subsidence

Soil subsidence (the lowering of the ground surface caused by such factors as compaction or a decrease in groundwater) can result from both natural and man-made phenomena. Natural phenomena that may induce subsidence include seismically induced settlement (liquefaction); soil consolidation; oxidation or dewatering of organic-rich soils; and collapse of subsurface cavities. Man-made activities such as withdrawing subsurface fluids through the pumping of groundwater may help induce subsidence by decreasing pore pressure.

Geologic conditions at the Project Site, consisting of a mix of alluvial sources, gravels and cobbles, are not prone to subsidence due to the lack of a seismically active area and the absence of unconsolidated, saturated, clay-free sands and silts.

Landslides

Landslides, rock falls, and debris flows are all forms of mass wasting, which is the movement of soils and rock under the influence of gravity. A landslide may occur if source material on a slope is triggered by some mechanism. Source materials include fractured and weathered bedrock and loose soils. Triggering mechanisms include earthquakes, saturation from rainfall, and erosion.

The *Five County Seismic Safety Element* identified four landslide risk categories. Areas of "no risk" were identified as flatlands, valley bottoms, and "areas of minimal topographic relief." Areas of "low risk" were identified as those along "hillside and mountains terrain of competent igneous and metamorphic rocks and sedimentary rocks with favorable bedding and composition." The "moderate risk" category includes "dip slopes (natural slopes parallel to bedding in sedimentary rocks), complexly folded metamorphic rocks, and zones of fractured rock." The "high risk" locations were those that consist of weak, landslide-prone rocks and existing or historical landslide locations. Therefore, landslide hazards within the County are locations along foothills and mountainous terrain, steep banks along rivers, and passes through valley floors (see Appendix H-1).

The Project Site consists of lands with less than 0.3 percent slope grade, and is therefore not subject to landslides.

Erosion

Erosion is the wearing away and removal of soils and/or rocks by natural forces. The main natural erosion forces are rainfall, wind, percolation of water that slowly dissolves rock, or landslides.

Erosion of the surface caused by rainwater is known as sheet-wash. Sheet-wash is described as water flowing across land picking up particles of soil or organic materials and carrying them away. Additionally, rainwater flows can cause rilling, which is when runoff water forms shallow broad channels across an area. Both sheet-wash and rilling leave patches of deposited soil material as a result of decreasing water velocity that can result from diminishing land gradient or from slackening rainwater. Wind erosion picks up small soil particles or bounces or rolls large particles along the land surface. Wind erosion is most serious when the soil is bare and exposed to strong wind.

Although all of these erosion processes are natural, human activity can multiply the frequency and size of the erosion event. Human activities that can increase erosion include:

- Reducing the rate by which water can enter the soil (e.g., covering the land with impervious surfaces such as houses, roads, and shopping centers), and thereby, promoting rapid runoff and greater erosive power of the water;
- Making drainage systems which concentrate runoff without controlling flow;
- Using poor agricultural practices such as overgrazing and cutting furrows down slope rather than with the natural contour of the land; and/or
- Excavating an area, which removes the vegetation and leaves the soil exposed to erosive factors.

While removal of soil for construction and mining operations could potentially cause increased erosion of topsoil at the Project Site, portions of the property surrounding the area disturbed by mining will remain vegetated, thus reducing the potential for erosion. Additionally, the Project Site consists of lands with less than 0.3 percent slope grade, and is therefore not prone to erosion.

4.2.2.3 Soils

Soils in the eastern part of Fresno County consist of younger alluvium, consolidated older alluvium, and hard rock. Most of the younger alluvium soils in eastern Fresno County have been washed down from the Sierra Nevada Mountains by rivers, streams, and creeks. Consequently, most of these younger alluvium materials are of granitic base. The older alluviums are generally composed of sedimentary materials from historical lake beds.

The Project Site is encompassed largely by three major soil types: Hanford fine sandy loam, Grangeville fine sandy loam, and Tujunga sand. Soil series are described in Figure 4.6-2 - Soils Map, and summarized below. Soil boundaries on Figure 4.6-2 are approximate, based on the location and soils observed in the soil profiles described and field observations along the traverse lines.

Soil Delineations and Map Unit Descriptions

The following soil types are included within the boundaries of the Project Site:

Map Unit – Hanford Series

These soils are very deep, well drained soils that formed in moderately coarse textured alluvium dominantly from granite. Hanford soils are on stream bottoms, floodplains and alluvial fans and have slopes of 0 to 15 percent.

Map Unit – He

This soil has gentle slopes ranging from 0 to 2 percent, and is more than 80 inches in depth to restrictive features (e.g., bedrock). These soils are well drained with an available water holding capacity of approximately 2 to 6 inches/hour.

Map Unit – Hm

This soil has gentle slopes ranging from 0 to 2 percent, and is more than 80 inches in depth to restrictive features (e.g., bedrock). These soils are well drained with an available water holding capacity of approximately 2 to 6 inches/hour.

Map Unit – Hn

This soil has gentle slopes ranging from 0 to 2 percent, and is more than 80 inches in depth to restrictive features (e.g., bedrock). These soils are well drained with an available water holding capacity of approximately 2 to 6 inches/hour.

Map Unit – Grangeville Series

These soils are very deep, somewhat poorly drained soils that formed in moderate coarse textured alluvium dominantly from granitic rock sources. Grangeville soils are on alluvial fans and floodplains and have slopes ranging from 0 to 2 percent.

Map Unit – Gf

This soil has gentle slopes ranging from 0 to 2 percent, and is more than 80 inches in depth to restrictive features (e.g., bedrock). These soils are poorly drained with an available water holding capacity of approximately 2 to 6 inches/hour.

Map Unit – Gl

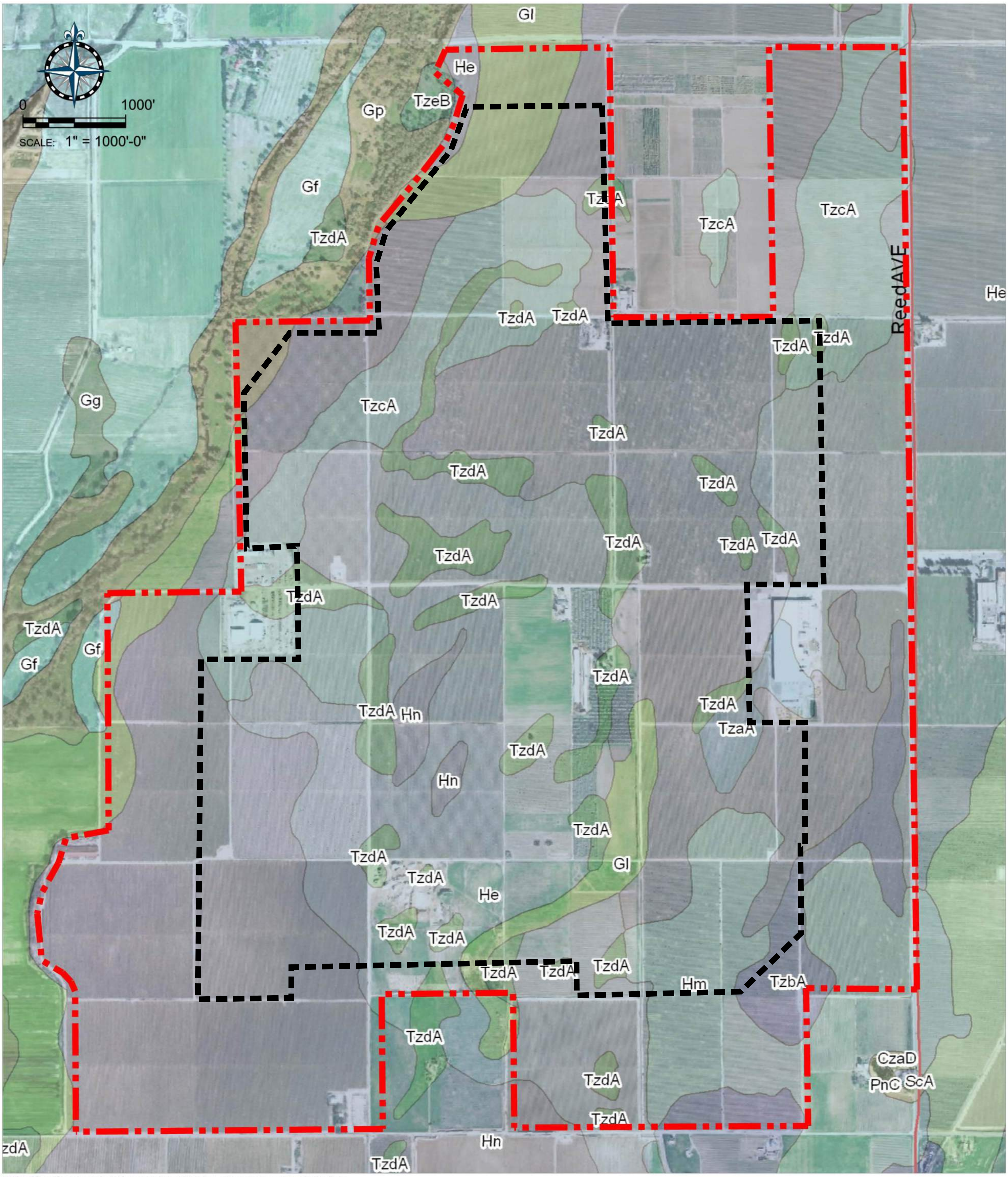
This soil has gentle slopes ranging from 0 to 2 percent, and is more than 24 to 48 inches in depth to restrictive features (e.g., bedrock). These soils are poorly drained with an available water holding capacity of approximately 2 to 6 inches/hour.

Map Unit – Gp

This soil has gentle slopes ranging from 0 to 2 percent, and is more than 80 inches in depth to restrictive features (e.g., bedrock). These soils are poorly drained with an available water holding capacity of approximately 2 to 6 inches/hour.

Map Unit – Tujunga Series

These soils are very deep, somewhat excessively drained soils formed in alluvium weathered mostly from granitic sources. Tujunga soils are on alluvial fans and flood plains and have slopes of 0 to 9 percent.



SOURCE: Department of Conservation, Division of Land Resource Protection

Site Boundary

Limits of Surface Disturbance

Hanford fine sandy loam, gravelly substratum (80"+ to restrictive feature)

Hanford sandy loam, gravelly substratum (80"+ to restrictive feature)

Grangeville fine sandy loam, gravelly substratum (24" to 48" to restrictive feature)

Grangeville fine sandy loam (80"+ to restrictive feature)

Grangeville soils, channeled (80"+ to restrictive feature)

Grangeville fine sandy loam, saline akali (80"+ to restrictive feature)

Tujunga sand (80"+ to restrictive feature)

Tujunga loamy sand (80"+ to restrictive feature)

Tujunga loamy sand, gravelly substratum (20" to 40" to restrictive feature)

Tujunga cobbly loamy sand (80"+ to restrictive feature)

Tujunga soils, channeled (80"+ to restrictive feature)

Source: Benchmark Resources, 12/2010.

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Soils Map

Carmelita Mine and Reclamation Project
County of Fresno, California

Figure 4.6-2

Map Unit – TzaA

This soil has gentle slopes ranging from 0 to 3 percent, and is more than 80 inches in depth to restrictive features (e.g., bedrock). These soils are excessively drained with an available water holding capacity of approximately 6 to 20 inches/hour.

Map Unit – TzbA

This soil has gentle slopes ranging from 0 to 3 percent, and is more than 80 inches in depth to restrictive features (e.g., bedrock). These soils are excessively drained with an available water holding capacity of approximately 6 to 20 inches/hour.

Map Unit – TzcA

This soil has gentle slopes ranging from 0 to 3 percent, and is more than 20 to 40 inches in depth to restrictive features (e.g., bedrock). These soils are excessively drained with an available water holding capacity of approximately 6 to 20 inches/hour.

Map Unit – TzdA

This soil has gentle slopes ranging from 0 to 3 percent, and is more than 80 inches in depth to restrictive features (e.g., bedrock). These soils are excessively drained with an available water holding capacity of approximately 6 to 20 inches/hour.

Map Unit – TzeB

This soil has gentle slopes ranging from 0 to 9 percent, and is more than 80 inches in depth to restrictive features (e.g., bedrock). These soils are excessively drained with an available water holding capacity of approximately 6 to 20 inches/hour.

4.2.2.4 Mineral Resources

The Surface Mining and Reclamation Act (SMARA) requires the State Geologist to classify land into Mineral Resource Zones (MRZs). These land classifications are based on the mineral potential of the area and do not consider the current or proposed land uses within the region. A description of these MRZ classifications is given as follows:

- **MRZ-1:** Areas where adequate information indicates that no significant mineral deposits are present or where it is judged that little likelihood exists for their presence.
- **MRZ-2:** Areas where adequate information indicates that significant mineral deposits are present or where it is judged that a high likelihood for their presence exists.
- **MRZ-3:** Areas containing mineral deposits, the significance of which cannot be evaluated from available data.

Due to the concerns regarding the availability of aggregate resources in the Fresno County area to meet current and future demands, the CGS examined the availability of aggregate resources in the region. The CGS findings were presented in a report entitled, *Update of Mineral Land Classification: Aggregate Materials in the Fresno Production-Consumption Region, California* (see Appendix H-1). The CGS report identified two main aggregate resource areas within the

County: the San Joaquin River Resource Area and the Kings River Resource Area. The San Joaquin River Resource Area contains MRZ-1 and MRZ-2 deposits, while the Kings River Resource Area contains entirely MRZ-2 deposits. Although the CGS findings identified the western side of the County as being in a MRZ-1, further evaluation of this area was not presented in their assessment. Additionally, the CGS identified the remaining area surveyed as being in a MRZ-3 location.

The San Joaquin River Resource Area is located along the northern county line of Fresno and Madera Counties. This resource area is part of the alluvial materials from the San Joaquin River and covers an estimated 4,271 acres (see Appendix H-1). The CGS has identified aggregate resources in this area as being MRZ-1 and MRZ–2. This resource area extends from the Lost Lake Recreation Area to the Riverside Municipal Golf Course, a distance of approximately 15 miles. The San Joaquin River Resource Area averages about 0.5 miles along its width. This resource area generally follows the historical floodplain of the San Joaquin River.

The Kings River Resource Area is an alluvial fan that underlies the Project Site. This resource area covers an estimated 16,380 acres (see Appendix H-1), including the 1,500-acre Project Site. (A map of the Kings River Resource Area alluvial fan is provided in Figure 4.10-2, Generalized Mineral Resource Zones, in Section 4.10.) The Kings River Resource Area is designated by the CGS as MRZ-2.

In 2006, the CGS updated aggregate demand and supply calculations for the 31 aggregate study areas in the State and these calculations revealed that the Fresno Production-Consumption region had less than 10 years of permitted aggregate resources remaining (see Appendix H-1). A Production-Consumption (P-C) region is one or more aggregate production districts (a group of producing aggregate mines) and the market area they serve (see Appendix H-1). As of 2006, the Fresno P-C Region had 71 million tons of permitted aggregate resources, a 27 percent reduction in permitted aggregate resources from five years earlier. Additionally, with only enough permitted aggregate resources to meet 11 percent of the Fresno P-C Region’s 50-year aggregate demand of 629 million tons, CGS estimated in 2006 that the Fresno P-C Region had less than 10 years of permitted aggregate resources remaining. In contrast to the 27 percent decrease in supply of permitted aggregate resources, the Fresno P-C Region’s demand for aggregate resources increased 11 percent between 2001 and 2006 to 629 million tons. These aggregate shortages in the County have resulted in aggregate materials being imported from areas outside the County such as Coalinga, a 120-mile round-trip haul (see Appendix H-1).

In addition, in the DOC’s 1999 report, *Update of Mineral Land Classification: Aggregate Materials in the Fresno Production-Consumption Region*, found that the County will need an excess of 527 million tons of aggregate over the following 25 years (DOC 1999). While this estimate was updated in 2006 to 629 million tons in the update to Map Sheet 52, Table 4.6-1, Current and Proposed Aggregate Supply in the Fresno P-C Region, provides the aggregate estimates for the Fresno region from that 1999 report, as well as recently permitted and project seeking permits in the region.

TABLE 4.6-1
CURRENT AND PROPOSED AGGREGATE SUPPLY IN FRESNO COUNTY

Current and Proposed Source	Total Reserves Over 50 Years (Million Tons)
Current Permitted Supply (Miscellaneous Sources)	71
Vulcan Sanger-Centerville Project	80
CMI Kings River Project	28
Jesse Morrow Mountain Project	100
Carmelita Mine and Reclamation Project	50
Vulcan Austin Quarry	125
Madera Quarry	45
Total	**499**
Needed (per DOC, CGS Map 52)	**629**

Development of identified aggregate resources is dependent upon a number of considerations, including the distance to market (job site) locations as transportation is one of the primary costs associated with aggregates. The farther aggregate is transported, the higher the cost for driver wages and truck operation (e.g., fuel and maintenance). Consequently, as the distance between the producing mine and the end user's location increases, the cost of aggregate material increases. For example, in 2006, the Fresno P-C Region's shortage of aggregate resulted in aggregate prices ranging between $14 and $18 per ton (see Appendix H-1). In contrast, the price of high-grade aggregate was half as much in areas with abundant permitted supplies, such as the Yuba City-Marysville Region, where aggregate ranged between $7 and $8 per ton.

Because aggregates are used in public projects, and a local cost-effective supply of aggregate construction materials is important for economic well-being, the State Mining and Geology Board encourages Lead Agencies to plan for a 50-year timeframe for aggregate supplies. With the ever-increasing population growth in the Fresno P-C Region, the CGS has predicted that a shortfall in the availability of aggregate products will occur in the area. While the CGS concluded in its 1999 report that the Fresno P-C Region would need an estimated 528 million tons of aggregate during the next 50 years (1998 to 2047), the 2006 report increased that estimate to 629 million tons.

4.6.3 Applicable Plans, Policies, and Regulations

4.6.3.1 Federal

The 1997 Uniform Building Code (UBC) was developed by the International Conference of Building Officials (ICBO) and is used by most states, including California, as well as local jurisdictions to set basic standards for acceptable design of structures and facilities. The UBC provides information on criteria for seismic design, construction, and load-bearing capacity associated with various buildings and other structures and features. Additionally, the UBC identifies design and construction requirements for addressing and mitigating potential geologic hazards. New construction generally must meet the requirements of the most recent version of the UBC.

4.6.3.2 State

4.6.3.2.1 Alquist-Priolo Earthquake Fault Zone Act

The State Alquist-Priolo Earthquake Fault Zoning Act of 1972 was passed to mitigate the hazards associated with surface faulting in California. Administered by the DOC, the Alquist-Priolo Earthquake Fault Zoning Act prevents construction of buildings used for human occupancy on the surface traces of active faults. Before a project can be permitted, cities and counties must require a geologic investigation to demonstrate that proposed buildings will not be constructed across active faults.

4.6.3.2.2 Seismic Hazards Mapping Act

The 1990 Seismic Hazards Mapping Act and related regulations established a statewide minimum public safety standard for mitigation of earthquake hazards. The purpose of this Act is to protect the public from the effects of strong ground shaking, liquefaction, landslides, or other ground failure as well as other hazards caused by earthquakes. The Act provides the minimum level of mitigation needed to reduce the risk of a building collapse. Under this Act, the lead agency can withhold permits until geologic investigations are conducted and mitigation measures are incorporated into building plans. In addition, the Act addresses not only seismically induced hazards but also expansive soils, settlement, and slope stability. The program and actions mandated by this Act closely resemble those of the Alquist-Priolo Earthquake Fault Zoning Act by requiring:

- The State Geologist to delineate various “seismic hazard zones”; and
- Cities, counties, and/or other local permitting authorities to regulate certain development “projects” within these zones by withholding the development permits for a site until the geologic and soil conditions are investigated and appropriate mitigation measures (if required) are incorporated into development plans.

4.6.3.2.3 California Building Code

The California Building Code (CBC), Title 24, CCR, Part 2, specifies the acceptable design and construction requirements associated with various facilities or structures. The CBC is administered and updated by the California Building Standards Commission. The CBC specifies criteria for open excavation, seismic design, and load-bearing capacity directly related to construction in the State. The CBC augments the UBC and provides information for specific changes to various sections in it. The seismic building requirements under the CBC are more stringent than the federal UBC.

4.6.3.2.4 Surface Mining and Reclamation Act (SMARA)

The Surface Mining and Reclamation Act (SMARA), and the State Mining and Geology Board Reclamation Regulations are flexible with respect to addressing geotechnical slope stability for both fill slopes and cut slopes. SMARA does not specify a minimum factor or safety for slope stability. However, Title 14, Chapter 8, CCR Section 3502(b)(3) indicates that final reclaimed slopes shall be flatter than the critical gradient, which implies that static factors of safety should be greater than 1.0. This section further states "Wherever final slopes approach the critical gradient for the type of material involved, regulatory agencies shall require an engineering analysis of slope stability. Special emphasis on slope stability and design shall be taken when public safety or adjacent property are affected."

Section 3704(d) states that fill slopes shall be 2H:1V or flatter. Fill slopes steeper than 2H:1V must be supported by site-specific geologic and engineering analyses to indicate that the minimum factor of safety is suitable for the proposed end use. The Proposed Project's design requires that all fill slopes are 2H:1V or flatter. The end use of the Proposed Project is agriculture with fruit trees and water basins that would be adaptable for irrigation use.

The Proposed Project has established a minimum mining offset of 100 feet from the Project Site boundaries and from the agricultural irrigation ditches. There are no dwellings located within 100 feet of the proposed mining limits. This minimum offset, in conjunction with mining depths limited to 50 feet, ensure that slope stability will not adversely impact adjacent property, irrigation ditches, or public safety.

In developing the slope stability criteria for the reclamation plan, the following issues were considered:

- The Project Site soils are dominated by granular soils. The critical failure surfaces are expected to be relatively shallow, which limits the horizontal impact of any slope instability. Furthermore, the potential for loss of strength due to displacement is expected to be limited for granular soils.

- With the exception of the interior slopes adjacent to the irrigation ditches, the interior slopes are not critical with respect to slope stability. The interior slopes simply provide convenient access and could be removed by the mining operation. In the event of a slope failure, the material is fully contained within the mining cells and therefore poses no impact to off-site sediment transport. Furthermore, the occurrence of shallow slope failures is not expected to adversely impact the agricultural operations.

4.6.3.3 Local

The County of Fresno General Plan identifies environmental, social and economic goals for the region, and sets forth policies, standards, and programs to guide physical development within the County. The following goals, objectives, and policies pertaining to the geology and soils as established by the County of Fresno General Plan, are applicable to this section of the DEIR.

Goal HS-D: To minimize the loss of life, injury, and property damage due to seismic and geologic hazards.

Policy HS-D.3: The County shall require that a soils engineering and geologic-seismic analysis be prepared by a California-registered engineer or engineering geologist prior to permitting development, including public infrastructure projects, in areas prone to geologic or seismic hazards (i.e. fault rupture, groundshaking, lateral spreading, lurchcracking, fault creep, liquefaction, subsidence, settlement, landslides, mudslides, unstable slopes, or avalanche).

Policy HS-D.4: The County shall require all proposed structures, additions to structure, utilities, or public facilities within areas subject to geologic-seismic hazards as identified in the soils engineering and geologic-seismic analysis to be sited, designed, and constructed in accordance with applicable provisions of the Uniform Building Code (Title 24 of the California Code of Regulations) and other relevant professional standards to minimize or prevent damage or loss and to minimize the risk of public safety**.**

Policy HS-D.7: The County shall ensure compliance with State seismic and building standards in the evaluation, design, and siting of critical facilities, including police and fire stations, school facilities, bridges, large public assembly halls, and other structures subject to special seismic safety design requirements.

Policy HS-D.8: The County shall require a soils report by a California-registered engineer or engineering geologist for any proposed development, including public infrastructure projects, that requires a County permit and is located in an area containing soils with high "expansive" or "shrink-swell" properties. Development in such areas shall be prohibited unless suitable design and construction measures are incorporated to reduce the potential risks associated with these conditions.

Policy HS-D.9: The County shall seek to minimize soil erosion by maintaining compatible land uses, suitable building designs, and appropriate construction techniques. Contour grading, where feasible, and revegetation shall be required to mitigate the appearance of engineered slopes and to control erosion.

4.6.4 Project Impacts and Mitigation Measures

4.6.4.1 Thresholds of Significance

Significant impacts to geology and soils would occur if any of the following occurs through implementation of the Proposed Project:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving;

  - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault (Refer to Division of Mines and Geology Special Publication 42);
  - Strong seismic ground shaking;

- Seismic-related ground failure, including liquefaction;
- Landslides.

- Result in substantial soil erosion or the loss of topsoil results;
- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on or off site landslide, lateral spreading, subsidence, liquefaction or collapse;
- Be located on expansive soil, as defined in Table 181-B of the California Building Code (2001) 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;

These thresholds were selected by the County of Fresno Department of Public Works and Planning to specifically address potentially significant impacts of the Proposed Project.

4.6.4.2 Issues Determined to Have No Impact

As a result of the analysis conducted for the DEIR, there are not any geological issues determined to have no impact with implementation of the Proposed Project.

4.6.4.3 Impacts Determined to be Less Than Significant

Would the project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving;

<u>Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map</u>

The Project Site is not within an Alquist-Priolo Earthquake Fault Zone. UBC has designated it as Seismic Zone 3, which can experience major damage due to earthquake. The closest known fault is the Clovis Fault located 5 to 6 miles east of the Project Site. It is classified as potentially active. Based on these facts, potential rupture from earthquake is considered less than significant.

<u>Strong Seismic Ground Shaking</u>

The Proposed Project is located in an area with a relatively low seismic hazard potential in comparison to most other regions in California. Earthquake hazard maps provided by the California Geologic Survey indicate the following:

- The design peak horizontal ground acceleration (PGA) in bedrock is estimated to be between 0.10g and 0.20g for an earthquake event associated with a 10 percent probability of exceedance (POE) in a 50-year period. Based on the location of the Project within the mapping, Golder estimated that the design PGA is approximately 0.15g or less.

- The earthquake associated with the above design PGA is associated with a magnitude 7.0 to 7.5 event located at least 100 kilometers from the site.

For sites located on thick soil deposits, such as the Project Site, it is common to apply a 10 percent reduction in the PGA estimated for PGA in bedrock. This potential reduction in design PGA was ignored in part due to the potential increases in the PGA that can occur with steep slopes (i.e. 1.5H:1V).

Based on the above facts, the risk of surface faulting and strong ground shaking at the Project Site is considered minimal. Potential impacts are determined to be less than significant.

Seismic-Related Ground Failure including Liquefaction or Landslides

Liquefaction is a process in which strong ground shaking causes saturated soils to lose their strength and behave as a fluid. Ground failure associated with liquefaction can result in lateral spreading and slope failure. Three geologic conditions must be simultaneously present for liquefaction to occur: shallow groundwater (less than approximately fifty feet deep), unconsolidated sandy soils, and strong ground shaking.

At the Project Site, groundwater occurs at depths of at least 15 feet or greater below the ground surface and within soils that are dominated by gravel and coarse sands. Based on these soil and groundwater conditions in conjunction with “the relatively low seismic ground shaking potential, the potential for liquefaction in the native soils at the Project Site is estimated to be low. For the preceding reasons, potential impacts are considered less than significant.

Landslides

Risk of landslide for flatlands, valley bottoms, and areas of minimal topographic relief is defined in the *Five County Seismic Safety Element*, as low risk. The Project Site consists of lands with less than 0.3 percent slope grade, and is therefore not subject to landslide. Potential impacts are determined to be less than significant based on the slope of the Project Site.

Result in Substantial Soil Erosion or the Loss of Topsoil

Existing orchards on the Project Site are flood-irrigated. Currently, irrigation and storm water runoff is controlled through a series of ditches and culverts. Mining and mine reclamation activities will be managed in the same manner by the use of ditches and culverts (refer to Figures 3-6 and 3-10). All stormwater will be maintained within active or reclaimed excavation areas where there is no exposed groundwater; therefore, no water will flow off the Project Site. Any rilling of soils which occur on excavation or reclamation slopes will be controlled through the construction or placement of these ditches and culverts or other methods of erosion control as stated in the Erosion Plan of the Reclamation Plan. Temporary measures such as silt fences, berms, hay bales or similar means to control erosion will be employed as necessary. Erosion control measures will also be employed on topsoil stockpiles. The following project operational actions will be implemented during operations and reclamation as needed:

EC-1 Areas that are no longer being actively utilized for mining would be stabilized with erosion control seed mix at the earliest feasible time.

EC-2 Final reclamation seeding shall be completed prior to October 15^{th} (or the first significant rains) of each season.

EC-3 Topsoil or overburden stockpiles that are anticipated to remain longer than one mining/reclamation season shall be seeded with an erosion control mix.

Soil mapping and description has been completed by the Natural Resource Conservation Service. As shown in Figure 4.6-2, topsoil and overburden will be stockpiled and used in concurrent reclamation to backfill portions of the previous mining cell to create useable fill slopes.

Drilling and trenching over the Project Site revealed that overburden varies from 0 to 20 feet deep, unevenly distributed on a cell-by-cell basis. As such, some mining cells may encounter limited, or conversely significant quantities for removal. Where sufficient quantities of topsoil are encountered, they would be placed in a manner to reach an elevation above the water table, such that the surfaces created could again be farmed. Therefore, while the acreage and location may vary, the fill profile would be consistent (fill matching the surrounding surface elevation). Overburden would be capped with a minimum of 3 feet of soil. It is estimated that 25 percent of the mined area could be backfilled and the rest would remain as open cells that could store water.

Redistribution of topsoil will be accomplished to establish stable, uniform thickness consistent with agricultural use, and to facilitate drainage patterns. Where distinct A, B, and C soil horizons exist, the topsoil will be separately stripped and stockpiled by horizon. Soil depth varies considerably across the Project Site, but it is the intent to redistribute soil to a depth of 36 inches. The following project operational actions will be implemented.

SMR-4 Topsoil and overburden will be separately stockpiled outside the current excavation area.

SMR-5 Topsoil stockpiles will be protected from inadvertent destruction or use by flagged staking or other identification and/or will be of sufficient distance from areas under active mining or surface disturbance.

SMR-6 Stockpiles will not be compacted, in order to maintain oxygen availability to soil micro-organisms. Topsoil will not be stripped or replaced during the rainy season or when soil is saturated.

Overburden and topsoil recovered during mining operations will be stockpiled and utilized in interim and final reclamation activities. Reclamation will proceed in accordance with the California State Water Resources Control Board regulations and as shown in Mine Plan Figures 3-11, 3-12, 3-14, and 3-17 for process fine backfill and stockpile locations.

On-site conditions in conjunction with operating actions indicate that on-site project-related soil erosion or loss of topsoil will have a less than significant impact.

Is Located on Expansive Soil as Designated in Table 18-1-B of the Uniform Building Code (1994) Creating Substantial Risks to Life or Property

The Project does not include any residential or commercial buildings; the only proposed structures are the portable aggregate equipment and associated administration offices. All additional construction would be operations-related. Appropriate measures which reduce the effects of earthquakes are identified in the Uniform Building Code (UBC), including specific provisions for seismic design of structures. The County has adopted the UBC for design and implementation of all structures, including the Proposed Project. Design of structures in accordance with the UBC and current professional engineering practices, would reduce the effects of seismic ground shaking below the level of significance.

Expansive soils have the unique physical characteristic to increase in volume when absorbing water and shrink when they dry out. Expansion is measured by shrink-swell potential, which is the relative volume change in soil with a gain in moisture. If the shrink-swell potential is rated moderate to high, damage to buildings, roads and other structures can occur. These expansive soils are present in a northwest-trending belt approximately parallel to the Friant-Kern Canal to the foothills in Kings Canyon National Park in the Sierra Nevada. These areas are concentrated north and northeast of the Project Site across the Kings River. No expansive soils exist on the Project Site; therefore, impacts from expansive soils are expected to be less than significant.

Have Soils Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Waste Water Disposal Systems Where Sewers are not Available for Disposal of Waste Water

The existing agricultural land use utilizes septic systems at both packing facilities and on-site residences. The systems operate adequately and there are no constraints to on-site septic. The aggregate plant and associated office may require a septic system for domestic wastewater containment. These would be subject to permit by Fresno County authorizing capacity, placement and feasibility. There are no known limitations to septic placement or operations on the Project Site.

4.6.4.4 Impacts Determined to be Potentially Significant

Is located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse.

Impact GEO-1:

The cut and/or fill slopes of the proposed excavations and levees may be unstable and fail under saturated conditions or due to seismic events. This is a potentially significant impact.

Cut Slopes Stability

The Proposed Project, as designed, anticipates final reclaimed cut slopes of 2V:1H or flatter. The following design criteria was utilized for consistency with SMARA.

Static and seismic slope stability analyses was conducted to evaluate stability of the proposed reclaimed quarry slopes for the Proposed Project. The computer program SLIDE 5.0 was used to calculate the factors-of-safety (FOS) against potential slope failures (see Appendix H-1). This program uses two-dimensional, limit-equilibrium theory to calculate safety factors and allows both circular and noncircular sliding surfaces to be either defined or generated automatically. Janbu's Method was used for FOS calculations. A third-party review was also conducted as part of preparing this DEIR. Review comments are included in Appendix H-2.

Pseudo-static analyses were performed to evaluate slope stability under earthquake loading. In a pseudo-static limit equilibrium analysis, a lateral force is added to a potential failure mass, with magnitude equal to some fraction of the weight of the slide mass. The fraction is defined in the form of a seismic coefficient, which is typically assumed to be less than the peak ground acceleration and is expressed as a percentage of gravity. Selection of a seismic coefficient and allowable FOS was based on the pseudo-static criteria established by Blake et. al (see Appendix H-1). This approach ties the selection of a seismic coefficient to the allowable permanent displacement (and other factors). Blake et al. (see Appendix H-1) developed charts for estimating the seismic coefficient for allowable displacements of 2 inches and 6 inches, which correspond to displacement sensitive applications. However, this methodology can be expanded to consider larger allowable displacements.

For the Proposed Project, the following seismic coefficients (k) using the approach of Blake et. al (2002) for the following allowable displacements were applied:

- Allowable displacement of 12 inches: k = 0.06.
- Allowable displacement of 24 inches: k = 0.043.

The following material properties were included in the stability modeling of the reclaimed slopes:

- **Overburden Soils**: The shear strength of the compact overburden soils (primarily sand) is assumed to be characterized by a friction angle of 35 degrees with no cohesion. A moist unit weight of 120 pcf was assumed for stability calculations. Although the observed temporary slopes at the Project Site suggest a much higher shear strength with friction angle greater than 50 degrees, this apparent high sheer strength is due in part to partially saturated conditions that increase capillary tension. This condition can change with changing moisture contents. Therefore, a friction angle of 35 degrees was considered more consistent with that observed for compact sands.

- **Alluvial Sands and Gravels**: The shear strength of the alluvial sands and gravels is assumed to be characterized by a friction angle of 38 degrees with no cohesion (Bowies, 1988). A moist unit weight of 130 pcf was assumed for stability calculations.

- **<u>Backfilled Mine Spoils</u>**: Mine spoils will consist of the overburden soils, excess sand, and the fines (silt and clay) screened or washed from the mined aggregate. A shear strength characterized with an internal friction angle of 32 degrees with no cohesion was assumed for this material if it is compacted to a minimum relative compaction of 90 percent per ASTM D 1557. For material that is track-walked in place with compaction by dozers and hauling equipment, the assumed internal friction angle was reduced to 28 degrees. The moist unit weight of the compacted mine spoils was assumed to be 112 pcf.

If degrees are used to mine the alluvial soils below the water surface, then backfilling of mine spoils will likely involve dumping the soils in a loose condition below the water table. Under this type of backfill placement, the mine spoils are expected to be relatively loose with considerably lower sheer strengths and unit weights.

Water levels at depths of 15 feet and 30 feet bgs were considered in the analyses and represent varying depths to groundwater for the majority of the Project Site. Seepage induced stresses were considered to be negligible for reclamation conditions. In addition, infiltration impacts from the agricultural ditches were considered negligible based on their minimum distances from the excavation slopes.

Aggregate mining operations can generate "muds" as a result of washing fines during the production of various aggregate products. For the purpose of this stability evaluation, the placement of saturated, soft muds within the backfill was not considered.

Fill Slopes and Stockpile Stability

Waste material would be generated during processing operations in the form of unmarketable material and/or fines. Because these materials would primarily result from processing operations, they would remain separate and distant from topsoil/overburden stockpiles generally stripped prior to excavation of raw material. Waste stockpiles, if any, would be located in the processing area and outside active mining areas until used in concurrent or final reclamation. Fill slopes would be limited to overburden backfill areas.

Slope Stability Results

The results the static and seismic analyses are summarized here. Calculations are included in Appendix H of this DEIR. A third-party review was also conducted as part of preparing this DEIR. Review comments are also included in Appendix H-2.

- For the native excavation slopes, a minimum static FOS of 1.14 was calculated for the 1.5H:1V slopes. If these slopes are flattened to 1.75H:1V, the minimum static FOS was calculated to be 1.3.
- For the native excavation slopes, a pseudo-static FOS of 1.0 was calculated for a seismic coefficient of 0.043 applied to the 1.5H:1V slopes. A pseudo-static FOS of 1.1 was calculated for native slopes inclined at 1.75H:1V for a seismic coefficient of 0.06. These calculations indicate that permanent displacements of 24 inches or less are expected for

1.5H:1V slopes, and permanent displacements of less than 12 inches are expected for 1.75H:1V slopes.

- For slopes backfilled with mine spoils compacted to a relative compaction of 90 percent or greater, a minimum static FOS of 1.2 was calculated. A corresponding pseudo-static FOS of 1.0 was calculated for a seismic coefficient of 0.043, indicating that permanent seismic displacements are estimated to be less than 24 inches.
- For slopes backfilled with mine spoils compacted by dozers and hauling equipment, a minimum static FOS of 1.2 was calculated for slopes flattened to 2.5H:1V. A corresponding pseudo-static FOS of 1.0 was calculated for a seismic coefficient of 0.043, indicating that permanent seismic displacements are estimated to be 24 inches or less.

For the backfilled mine spoils conditions, the above analyses assumed that height of the backfilled slopes was 50 feet. The slope heights will be considerably less for the cells that are backfilled above the groundwater surface.

The analyses indicated only minor differences in the computed FOS between assumed groundwater depths of 15 feet and 30 feet. In both cases, it was assumed that the water level in the pond was in equilibrium with the surrounding groundwater levels.

Mitigation Measures

Based on the slope stability analyses and slope stability criteria established for the Proposed Project design, the following mitigation measures are recommended.

Mitigation Measure GEO-1:

Under a dewatering scenario, dewatering wells will be used to lower groundwater levels sufficiently behind the slope face as necessary to maintain a minimum factor of safety of 1.3 under static conditions while considering the groundwater conditions within the slope. The factor-of-safety shall be measured using the computer program SLIDE 5.0 (see Appendix H-1) and reported to the County.

Mitigation Measure GEO-2:

Any waste material shall be stockpiled and stored in the processing area, separated from overburden/topsoil stockpiles, and used to elevate the quarry floors in various cells as available and as necessary to reach final reclaimed design elevation.

Mitigation Measure GEO-3:

Backfilled mine spoils that are compacted to minimum relative compaction of 90 percent per ASTM D1557 shall be inclined at 2H:1V.

Mitigation Measure GEO-4:

Backfilled mine spoils that are placed in controlled lifts of no more than 12-inches thick and compacted by track walking by dozers and hauling equipment on perimeter slopes and interior slopes adjacent to the agricultural water ditches shall be inclined at 2.5H:1V.

Mitigation Measure GEO-5:

Dredging may result in the need to backfill soils below the groundwater. For this scenario, the backfill will likely exhibit lower shear strengths than assumed in the stability analyses and will likely require substantially flatter backfill slopes. Additional geotechnical studies shall be completed to assess the shear strength of hydraulically placed soils and the required backfilled slope inclination. These studies shall be completed following commencement of the mining operations after mine spoil properties can be better characterized, but regardless, shall be completed prior to any dredging operations. If the studies determine that substantially flatter slopes are required, these changes will be incorporated into the backfill slope design.

Mitigation Measure GEO-6:

If the mining operations generate "muds," the muds shall be dried and compacted as backfilled mine spoils. Alternatively, it may be possible to incorporate the muds into the mine spoils backfill without drying and compaction provided geotechnical studies (prepared by a County-approved geotechnical expert) are completed to define the maximum mud lift thickness and horizontal offset from the final slope face that will result in a static factor of safety of 1.2 and less than 24 inches of seismic displacement.

Level of Significance After Mitigation:

Impacts to or from geological materials and conditions would be less than significant with implementation of Mitigation Measures GEO-1 through GEO-6.