# 4.5 GEOLOGY AND SOILS

## 4.5.1 Introduction and Methodology

The following discussion of geology and soils is based on site reconnaissance and review of pertinent geological and soils reports and maps for the proposed desalination plant site and offsite project elements, as well as a geotechnical report addressing construction of the desalination plant (GeoLogic Associates, 2004), included as APPENDIX G. The geotechnical study included a review of pertinent geological literature and maps, field reconnaissance of the existing site conditions, subsurface exploration borings, laboratory testing of soil samples, and geotechnical and environmental analyses.

General geologic and soil resource conditions for the offsite project elements, including the different pipeline alignments and the pump station, were researched through the use of a July 2, 2004 geotechnical letter report prepared by Carollo Engineers (APPENDIX G), supplemented by reports and data produced by the California Department of Conservation (DOC), the California Geological Survey (CGS, formerly the Division of Mines and Geology), San Diego State University Geology Department, the general plans of the affected cities, the City and County of San Diego online geographical database (www.SanGIS.org), and the U.S. Department of Agriculture Natural Resource Conservation Service (NRCS, formerly the Soil Conservation Service). A complete listing of these references is included in *Chapter 9.0*.

## 4.5.2 Existing Conditions

The study area for the existing conditions discussion includes those areas immediately surrounding the desalination plant site and offsite project elements, except where noted differently.

### General Setting

The proposed project site, including the proposed desalination plant site and offsite project elements, is situated on the coastal plain of the Peninsular Ranges Geomorphic Province of California. The coastal plain has undergone several episodes of marine inundation and subsequent marine regression throughout the last 54 million years, resulting in deposition of a thick sequence of marine and non-marine sedimentary rocks on the uplifted and eroded high-relief basement terrain. Gradual emergence of the region from the sea occurred in Pleistocene time, and numerous wave-cut platforms, most of which were covered by relatively thin marine and non-marine terrace deposits, formed as the sea receded from the land. Accelerated stream erosion during periods of heavy rainfall, coupled with the lowering of the base sea level during

Quaternary times, resulted in rolling hills, mesas, and deeply incised canyons which characterize the landforms presently occurring in the study area.

### Rock Formations and Soils

The general vicinity of the proposed desalination plant site is underlain by Tertiary marine sediments capped by Quaternary marine and non-marine sediments deposited on wave-cut terraces. Each marine terrace was formed during a Pleistocene sea level high stand, and tectonically uplifted. Each subsequent sea level rise produced a new terrace, eventually forming a series of terraces along the modern shoreline, with the oldest terrace occupying the highest elevation. Based on subsurface exploration conducted by GeoLogic Associates, the majority of the desalination plant site is underlain by artificial fill and very light brown to green-brown silty sandstone interbedded with siltstone (GeoLogic Associates 2004), mapped as mid-Eocene Santiago Formation (DOC 1996). Based on the exploratory borings, artificial fill soils were determined to have a low expansion potential (GeoLogic Associates 2004). Santiago Formation soils were found to underlay the fill soils, consisting of silty sandstone, as well as lagoonal deposits and residual soils. According to NRCS maps, the plant site is underlain by Marina loamy coarse sand, 2 to 9 percent slopes, with slight to moderate erosion hazard (NRCS 1973). Groundwater at the proposed plant site was observed in formational deposits at depths ranging from 20.8 to 28.9 feet (elevation of 1.1 to 14.2 feet above mean sea level), and the groundwater levels are anticipated to vary seasonally (GeoLogic Associates 2004).

The geotechnical study prepared for the desalination plant site included sampling of the near-surface fill soils. Samples of the formational materials were tested for their load-settlement characteristics by performing a consolidation test at representative intervals. The results of the consolidation tests indicate the expansion potential of the onsite fill soils to be in the low range (expansion index from 21 to 50 per the UBC, 1997 (GeoLogic Associates 2004)).

For the portion of the study area that includes the project's offsite elements, the study area contains ten general soil associations as indicated by the DOC's San Diego County Soil Survey (1996). Soils associations are useful for developing a general idea of the soils in an area and for determining the value of an area for certain uses. The following outlines these soil classifications.

- ***Marina-Chesterton Association:*** This association consists of somewhat excessively drained to moderately well drained loamy coarse sands and fine sandy loams that have a subsoil of sandy clay over a hardpan. This soil type is located between sea level and 400 feet above mean sea level and occurs on grades of 2 to 15 percent (NRCS 1973).

- ***Salinas-Corralitos Association:*** This consists of moderately well-drained to somewhat excessively drained clays, clay loams, and loamy sands on alluvial fans, on 0 to 9 percent slopes.

- ***Cieneba-Fallbrook Association (Very Rocky):*** These soils are excessively drained to well-drained coarse sandy loams and sandy loams that have a sandy clay loam subsoil over decomposed granodiorite. These soils occur between 200 and 3,000 feet above mean sea level and occur on 9 to 75 percent slopes.

- ***Exchequer-San Miguel Association:*** Rocky, well drained silt loams over metavolcanic rock, typically on 0 to 30 percent slopes.

- ***Diablo-Altamont Association:*** Well drained clays are the major characteristic of this association, normally found on 5 to 15 percent slopes.

- ***Diablo-Las Flores Association*****:** This association consists of well drained clays and moderately well drained loamy fine sands that have a subsoil of sandy clay. These soils occur between 100 and 600 feet above mean sea level and occur on 9 to 30 percent slopes (NRCS 1973).

- ***Las Flores-Huerhuero Association:*** This association consists of moderately well-drained loamy fine sands to loams that have a subsoil of sandy clay or clay; 9 to 30 percent slopes.

- ***Ramona-Placentia Association:*** This association consists of well drained and moderately well drained sandy loams to sandy clay over granitic alluvium. This soil type is largely in foothills between 200 and 1,800 feet above mean sea level and occurs on grades of 2 to 15 percent.

- ***Fallbrook-Vista Association (Rocky):*** These soils consist of well-drained sandy loams and coarse sandy loams that have a subsoil of sandy clay loam and sandy loam over decomposed granodiorite. These soils occur between 200 and 2,500 feet above mean sea level and occur on 9 to 30 percent slopes.

- ***Friant-Escondido Association (Eroded):*** These soils are excessively well drained fine sandy loams and very fine sandy loams over metasedimentary rock. These soils occur between 400 and 3,500 feet above mean sea level and occur on 30 to 70 percent slopes (NRCS 1973).

### Faulting

Based on the commonly accepted definition provided by the California Geological Survey, an active fault is a fault that has had surface displacement within Holocene time (about the last 11,000 years). The state geologist has defined a potentially active fault as any fault considered to have been active during Quaternary time (last 1,600,000 years). This definition is used in delineating Earthquake Fault Zones as mandated by the Alquist-Priolo Geologic Hazards Zones Act (California Public Resources Code Sections 2621-2630). The intent of this act is to assure that unwise urban development and certain habitable structures do not occur across the traces of active faults. The seismic safety or public safety elements of general plans of the affected jurisdictions, including the cities of Carlsbad, Oceanside, and Vista, regulate the placement of structures within their respective City limits.

The proposed desalination plant site is not included within any Earthquake Fault Zones as defined by the Alquist-Priolo Act, and the review of available geo1ogic literature indicated that no known major or active faults are located on or in the immediate vicinity of the site (GeoLogic Associates 2004, *Figure 4.5.1*). The nearest active regional faults are the Rose Canyon Fault Zone and the Newport-Inglewood Fault (offshore) located approximately 4.3 and 5.6 miles from the site respectively (*Table 4.5.1).* Regional fault systems, including the San Jacinto, San Andreas, and Elsinore Faults are located to the east and north of the study area, and the closest of the three, the Elsinore Fault, is over 20 miles to the east.

**TABLE 4.5.1**
**Seismic Parameters for Active Faults**

| Fault Zone (Seismic Source) | Distance to desalination plant Site (miles) | Maximum Earthquake Event | | Design Earthquake* |
|---|---|---|---|---|
| | | Moment Magnitude | Peak Horizontal Ground Acceleration (g) | Peak Horizontal Ground Acceleration (g) |
| Rose Canyon | 4.3 | 6.9 | 0.31 | 0.28 |
| Newport-Inglewood (Offshore) | 5.6 | 6.9 | 0.27 | |
| Coronado Bank | 20.4 | 7.4 | 0.14 | |

**Notes:** * per UBC, 1997
**Source:** GeoLogic Associates 2004

Seismic conditions for offsite project components is generally similar to that described for the proposed desalination plant site. Although this region in known to have the potential for seismic events, there are no known faults within the area, and no Alquist-Priolo Special Study Zones have been identified (City of Carlsbad 1994).

Figure 4.5-1

### Regional Seismicity

Southern California is considered a seismically active region. From a deterministic standpoint, *Table 4.5.1* identifies potential seismic events that could be produced by the maximum (formerly referred to as maximum credible) earthquake event.

The historic record of earthquakes in Southern California for the past 200 years has been reasonably well established. Based on recorded earthquake magnitudes and locations, the study area may be vulnerable to moderate seismic ground shaking during the design life of the project. Review of historic earthquakes indicates that the most significant seismic event that impacted the proposed desalination plant site over the last 200 years was a Magnitude 6.5 earthquake event on the Rose Canyon Fault. This earthquake occurred in 1800 approximately 9.8 miles from the site, and was estimated to have caused a site acceleration of 0.19g at the site (GeoLogic Associates 2004).

### Liquefaction and Seismic Lurching

Liquefaction is a phenomenon in which soils lose shear strength for short periods of time during an earthquake, which may result in differential settlements for structures founded on liquefiable soils. In order for the potential effects of liquefaction to be manifested at the ground surface, the soils generally have to be granular, loose to medium dense, saturated relatively near the ground surface, and must be subjected to a sufficient magnitude and duration of shaking. Among granular soils, finer textured varieties are most susceptible to liquefaction than coarse-grained types, and soils of uniform grain size are more likely to liquefy than well-graded materials.

A liquefaction evaluation of the proposed desalination plant site was performed as part of the geotechnical investigation (GeoLogic Associates 2004). The overall subsurface profile and the overlying thickness of non-saturated soils (non-liquefiable soils) indicate that the potential for large-scale liquefaction at the site during the life of the structure is very low (GeoLogic Associates 2004). In addition, based on the age of the formational deposits (Tertiary materials of the Santiago Formation are on the order of 50 million years old), large-scale liquefaction effects at the ground surface are not considered likely.

Offsite of the desalination plant, there are limited areas in the project study area which are considered potentially subject to liquefaction, including areas west of El Camino Real, the areas in and around lagoons, and along the beaches (City of Carlsbad 1994).

Soil lurching refers to the rolling motion on the ground surface by the passage of seismic surface waves. Effects of this nature are likely to be a concern where the thickness of soft sediments vary appreciably under structures.

### Landslides

The power plant site is located in a gently sloping area with slight topographic relief. Topography of the pipeline routes vary greatly, from mostly flat alignments within existing street right-of-ways to gently sloping hillsides and canyons. Overall, the potential for landslides for the desalination plant and offsite project elements is expected to be low, since there is little topographic relief and pipeline facilities will be placed underground.

### Tsunamis and Seiches

A tsunami is a sea wave generated by submarine earthquakes, landslides or volcanic activity, which displaces a relatively large volume of water in a very short period of time. Several factors at the originating point such as earthquake magnitude, type of fault, depth of earthquake, focus, water depth, and the ocean bottom profile contribute to the size and momentum of a tsunami (GeoLogic Associates 2004). In addition, factors such as the distance away from the originating point, coastline profile (including width of the continental shelf) and angle at which the tsunami approaches the coastline also affect the size and severity of a tsunami.

There have been over 500 tsunamis reported with recorded history worldwide, most of them generated at subduction-convergent plate boundaries along the margin of the Pacific Ocean. Large tsunamis have been occurring in the Pacific Basin at an average rate of roughly 1 every 12 years (GeoLogic Associates 2004). Most complete reports along the California coast are available from San Diego and San Francisco where tide gauges were installed in 1854 (GeoLogic Associates 2004).

Nine great tsunamis have occurred in the past that have generated wave heights in excess of 0.65 feet (0.2 meters) in San Diego, and represent each of the major generating zones within the Pacific Basin (GeoLogic Associates 2004). Of these, two were locally generated in California. One of these occurred in San Diego Bay in 1862 and was the only locally generated tsunami that has affected San Diego. The tsunami was associated with an earthquake that caused the most intense shaking locally known, and was evidenced by eyewitness account only. The second California tsunami was off of Point Arguello (Santa Barbara County) in November 1927 with a magnitude of 7.3M, and is the only well-documented locally generated tsunami in California history. This tsunami produced wave height of approximately 0.16 feet (0.05 meters) in La Jolla, arriving within one hour.

Tsunami wave heights and runup elevations experienced along the San Diego coastline during the last 170 years have fallen within the normal range of tidal fluctuations (approximately 9 feet). The predicted average tsunami height in the San Diego region for an event with a 10% probability of being exceeded in 50 years is approximately 11.5 feet mean sea level (GeoLogic Associates 2004), indicating a low potential for significant tsunami effects at the desalination plant site, since the site elevation is above 30 feet mean sea level (MSL). Southern California is oriented obliquely (i.e. not directly in line) with the major originating tsunami zones, and it has a relatively wide (about 150 miles) and rugged continental shelf, which acts as a diffuser and reflector of remotely generated tsunami wave energy (GeoLogic Associates 2004). These conditions, in addition to the geologic and seismic conditions (such as the strike-slip fault regime, and the scarcity of large submarine earthquakes) along the coastline also tend to minimize the likelihood of a large tsunami at the site. Based on these factors, there is low potential for catastrophic damage along the San Diego County coastline.

Seiches are defined as oscillations in a semi-confined body of water due to earthquake shaking. The proposed desalination plant site would be located approximately 200 feet from the Agua Hedionda Lagoon, at a site elevation at 30 feet above MSL.

### Mineral Resources

The Surface Mining and Reclamation Act of 1975 requires the State Board of Mining and Geology and the State Geologist to prepare mineral resource reports that designate mineral deposits of statewide or of regional significance. The process involves classification and designation. Classification inventories select mineral commodities within a defined study area. These are areas where adequate information indicates that significant mineral deposits are present or where it is judged that a high likelihood for their presence exists. Designation identifies deposits of regional or statewide significance which are available from a land use perspective. The CGS characterizes mineral potential according to their Mineral Resource Zone (MRZ) categories. Areas classified as MRZ-1 are considered to have little likelihood of containing significant deposits suitable for production as high-quality aggregate. Areas classified as MRZ-2 have a high likelihood that significant deposits of PCC grade aggregate exist. Areas classified as MRZ-3 are areas containing aggregate deposits, the significance of which cannot be evaluated from existing data or available information. And finally, MRZ-4 denotes areas where not enough information is known to determine if mineral deposits are present or if they are significant. These areas do not fit into any other MRZ zone (CGS 1996).

The proposed desalination plant site is located in an MRZ-3 zone, as is the majority of the area within the City of Carlsbad (CGS 1996). Two areas adjacent to the offsite pipelines are designated as MRZ-2, corresponding to the South Coast Materials Company Carlsbad Quarry (immediately south of SR78/College Boulevard intersection), and to the far north within the City of Oceanside, at the San Luis Rey River basin. In the case of the San Luis Rey River, the basin contains landfill and beach sand and construction quality sand (City of Oceanside 1975). Another adjacent quarry in the City of Oceanside, is designated MRZ-4, indicating that it is an area where available information is inadequate for assignment to any other MRZ zone (CGS 1996).

### 4.5.3 Significance Criteria

The project would have a significant effect related to geology and soils if it would:

a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury or death involving:

   (i) 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 (based on the Division of Mines and Geology Special Publication 42);

   (ii) Strong seismic ground shaking;

   (iii) Seismic-related ground failure, including liquefaction; or

   (iv) Landslides;

b) Result in substantial soil erosion or the loss of topsoil;

c) 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;

d) Be located on expansive soils, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property;

e) Result in the loss of availability of a known mineral resource that would be of future value to the region and the residents of the State; or

f) Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan.

## 4.5.4 Impacts

### Desalination Plant Site

#### *Soils*

In general, the geotechnical evaluation determined that the existing onsite desalination plant soils would be suitable material for structural fill construction (GeoLogic Associates 2004). More detailed information follows.

During construction of the proposed desalination plant, erosion could be accelerated which could undermine slopes, create siltation of surface waters, and expose and damage underground facilities. Implementation of the project will require grading to remove the inner earthen wall of the containment berms surrounding the existing fuel oil storage tank, and to compact and smooth the existing topography of the site. Otherwise, the existing berms will remain intact. Construction activities associated with the proposed project will temporarily expose underlying soils, thereby increasing their susceptibility to erosion until the project is fully implemented. While loss of soil onsite would not lead to any substantial impacts to the site itself, erosion resulting from site preparation could affect water quality downstream of the project site. Water quality impacts related to soil erosion are considered to be significant. In order to reduce these potential short-term erosion impacts, mitigation is required (see *Section 4.7.5, Water Quality and Hydrology*). As detailed in the Water Quality and Hydrology discussion, all aspects of the project will conform with applicable National Pollutant Discharge Elimination System (NPDES) permit requirements, including the incorporation of a Storm Water Pollution Prevention Plan (SWPPP) employing Best Management Practices (BMPs) to control soil erosion, sedimentation and turbidity.

Some components of the desalination plant facility, including the proposed lowest elevation of the RO Building, are proposed to be located on recompacted fill soils. Also, the proposed pretreatment filter area is planned to be founded across a fill-formational contact. Without proper grading and recompaction or remedial design features for building foundations, impacts related to soil stability are considered significant. To mitigate for impacts related to structural stability, mitigation measures have been included to provide for appropriate soil engineering specifications.

The groundwater table at the desalination plant site was encountered during drilling at a depth of 20.8 to 28.9 feet below the existing ground surface (or at an approximate elevation of 1.1 to 14.2 feet mean sea level). At this depth, the proposed finish floor elevations of all desalination plant facilities would be a minimum of 10 to 15 feet above the highest groundwater level. As such, groundwater issues would not pose a substantial constraint or hazard to project development. Therefore, no significant soil suitability impacts that would be related to groundwater proximity are anticipated.

Based on the results of subsurface exploration and laboratory testing, the pad grade fill soils are generally considered to have a low expansion potential using the UBC standard (GeoLogic Associates 2004). Therefore, significant impacts related to expansive soils are not anticipated.

Based on the above discussion, soil stability issues that could result in potentially significant impacts require mitigation. No other feature of the proposed project at the desalination plant site would result in the exposure people or structures to potential substantial adverse effects related to soils and erosion, including the risk of loss, injury or death, and no additional significant impacts are anticipated.

### *Faults and Seismic Hazards*

The maximum earthquake is defined by the State of California as the maximum earthquake that appears capable of occurring under the presently understood tectonic framework. Site-specific seismic parameters included in *Table 4.5.1* are the distances to faults, earthquake magnitudes (Mw), and expected ground accelerations.

As indicated in *Table 4.5.1*, the Rose Canyon Fault is the active fault considered to have the most substantial effect at the site from a design standpoint. The maximum earthquake from the fault has a 6.9 moment magnitude, generating a peak horizontal ground acceleration of 0.31g at the project site.

From a probabilistic standpoint, the design ground motion (per UBC, 1997) is defined as the ground motion having a 10 percent probability of being exceeded in 50 years. This ground motion is referred to as the design earthquake. The design earthquake ground motion at the site is predicted to be 0.28g (GeoLogic Associates 2004). The effect of seismic shaking would be reduced by adhering to the Uniform Building Code and state-of-the art seismic design parameters of the Structural Engineers Association of California. Accordingly, impacts related to seismic shaking would not significantly expose people or structures to potential substantial adverse effects, including the risk of loss, injury or death. Impacts would be less than significant.

Secondary effects associated with severe ground shaking following a relatively large earthquake on a regional fault that may affect the site include ground lurching, soil liquefaction, seiches, and tsunamis. These secondary effects of seismic shaking are discussed below.

### *Liquefaction and Seismic Lurching*

As described in *Section 4.5.1*, the liquefaction evaluation determined that the overall subsurface profile and the overlying thickness of non-saturated soils (non-liquefiable soils) indicate that the potential for large-scale liquefaction at the desalination plant site during the life of the structure is very low (GeoLogic Associates 2004). In addition, based on the age of the formational deposits (Tertiary materials of the Santiago Formation are on the order of 50 million years old), large-scale liquefaction effects at the ground surface are not considered likely. Also, current standards in the UBC are intended to reduce the potential for major structural damage and will be adhered to during the design and construction of the proposed project. Therefore, the potential for liquefaction effects on the proposed structures are not sufficient to be considered a significant impact.

Damage to the proposed desalination plant as a result of seismic lurching would not be significant since a relatively large differential fill thickness does not exist below the desalination plant site.

### *Landslides*

The desalination plant site is located in a gently sloping area with slight topographic relief and is not considered to be subject to landslides. Also, the project would be designed in accordance with UBC standards thereby reducing the potential for instability issues related to landslides. Accordingly, the potential for landslides or other slope instability problems is considered to be low, and impacts would be less than significant.

### *Tsunamis and Seiches*

As described in *Section 4.5.1*, tsunami wave heights and runup elevations experienced along the San Diego coastline during the last 170 years have fallen within the normal range of tidal fluctuations, and the potential for significant tsunami effects at the desalination plant site is considered to be low (GeoLogic Associates 2004). This determination is bolstered by the fact that the orientation of Southern California and its geographic and seismic factors are not conducive to tsunamis (i.e., oblique orientation with respect to major originating tsunami zones, wide and rugged continental shelf, and scarcity of large submarine earthquakes). Based on these factors, there is low potential for catastrophic damage along the San Diego County coastline resulting from tsunamis, and impacts would be less than significant.

In Carlsbad, a seiche would not be expected to affect areas 5 to 10 feet above lagoon water level (City of Carlsbad South Coastal Redevelopment Plan 2000). As the proposed desalination plant site would be located 30 feet above mean sea level relative to the Agua Hedionda Lagoon, the potential for seiches to affect the site are considered low and impacts would be less than significant.

### *Mineral Resources*

The proposed desalination plant site is located within an MRZ-3 zone (DOC 1996). The site-specific geotechnical investigation for the plant site did not reveal the presence of important mineral resources, and therefore impacts related to the loss of availability of a known mineral resource that would be of future value to the region and the residents of the State would be less than significant. Also, the project site has not been delineated as an important mineral resource recovery site within the City of Carlsbad's General Plan. Therefore no impacts related to the loss of availability of a locally important mineral resource recovery site are anticipated.

## Offsite Project Elements

The impact analysis for the offsite project elements first considers that depending on the selected alignment, approximately 50 to 80 percent of the pipeline would be located within existing road right-of-ways. For these pipelines, issues involving constructability, seismic hazards, landslides, liquefaction, and mineral resources are not anticipated to pose substantial constraints on project development, given the developed nature of the existing roadways and the fact that various utility lines currently exist along the alignment. However, a geotechnical evaluation of the selected pipeline alignment will be required by the Cities of Carlsbad, Oceanside and Vista prior to approval of any required encroachment permits. Therefore, this requirement has been included as a project mitigation measure. The geotechnical evaluation would evaluate soils, seismicity, hazards, groundwater, and structural design issues for all offsite project components. It should also be noted that pipeline construction would be subject to erosion control measures identified in *Section 4.7.5, Water Quality and Hydrology*.

As stated previously, the majority of the pipeline alignments will occur within existing public streets, easements, or other rights-of-way (ROW). Although precise pipeline alignments may be modified during final engineering analyses, the conceptual pipeline alignments are shown in *Figure 3-5*. A detailed description of the different pipeline alignments is included in *Section 3.4*.

### *Soils*

Potentially significant construction-related impacts associated with the project include encountering unstable soil and rock conditions and exposure of oversize rock material during grading. Potential impacts could also arise from temporary stockpiling during pipeline construction activities.

The specific soil types each off-site project component will impact are unknown at this time. However, a preliminary geotechnical review of the project area has been prepared to identify potential building and environmental constraints associated with the water delivery pipelines (Carollo Engineers 2004). Based on this report, it is assumed that native soils excavated in the project area would be suitable for backfill and compaction for conventional pipeline construction. It is expected the soil composition is made up of loose to medium dense, potentially compressible sands and silty sands. If rock conditions are encountered, other methods of construction may be required to accommodate cutting rock. Soil conditions near the coast are expected to be cohesionless sandy soils. Design of the trench and pipe within this coastal area will require special attention to prevent undermining any surface improvements including roadways and appurtenant structures or below ground utilities. Earthwork for the project will likely comprise site preparation, excavation, fill placement, and trench backfill and compaction of compressible soils.

The design of the project components would be accompanied by a geotechnical evaluation, identified as a mitigation measure in *Section 4.5.5,* during the design phase of the pipelines and pump station, to verify preliminary assessments and to determine appropriate construction techniques. The results of the geotechnical study may influence the ultimate selection of alignment segments. As noted in *Section 3.4*, multiple and redundant pipeline alignment segments have been identified for analysis to provide flexibility in the selection of the ultimate alignment and configuration of offsite facilities. The geotechnical evaluation will also characterize the project area geology, determine the suitability of native soils for reuse within the excavation area, and make recommendations for safe excavating and shoring of open cuts for conditions relative to project-specific needs.

The geotechnical study would yield additional information regarding content, stability, potential for subsidence and compactibility. This data will then be used during project planning and design for the offsite project elements. The geotechnical study will detail appropriate measures, as necessary, to be incorporated into the design to remediate any unsuitable soils conditions that may be encountered. Implementation of this mitigation measure would ensure that the potential for significant geology and soils impacts would be less than significant.

### *Landslides, Liquefaction and Seismic Lurching, Faults and Seismic Hazards*

Landslide areas in Carlsbad are mainly found on the north-facing slopes along creek channels. Topography of the pipeline routes vary greatly, but landslide hazards associated with the pipelines is considered to be minimal, since the facilities would be placed underground and ground surface topography would be restored to pre-project conditions.

None of the offsite project elements are anticipated to traverse known faults associated with the Rose Canyon Fault System. Additionally, due to the project design feature which requires that all project components be constructed in accordance with UBC requirements related to protection against seismic instability, liquefaction, seismic lurching hazards, and stability impacts would be less than significant. Implementation of the proposed project would not result in substantial adverse effects to people or structures from landslides or seismic activity.

The proposed project components may be locally subject to seismically induced secondary effects related to liquefaction, lateral spreading, local subsidence of soil, and vibrational damage. Pipelines are installed typically by trenching and backfill, underground. The pipe is supported on bedding material, and at least six to eight inches of clearance is left between the pipe and trench walls. Suitable granular pipe zone material is placed around and on top of the pipe. Backfill must consist of suitable material, free of organic material, debris, and large rocks. This construction method absorbs energy during seismic events and relieves susceptibility to ground motion that would cause rupture of the pipe.

Various pipeline materials will be considered during the design of the off-site distribution piping system including steel pipe, concrete cylinder pipe, and ductile iron pipe. Specific criteria apply to each type of system as defined in standards and specifications including the American Water Works Association (AWWA) and the American Society for Testing and Materials (ASTM) among others. Pipeline design does not directly apply factors based on earthquake loading because of the variables involved, but design considerations, such as the use of flexible couplings to join two pipe systems, allow the pipe to resist the effects of an earthquake to a degree. Buried pipeline systems have flexible joints to allow a certain degree of deflection. Trench bedding, fill, and backfill materials and installation requirements are specified to allow for the greatest degree of continuous pipe support. As a standard condition, engineered structures for this project must be designed for conditions of seismic risk zone 4, which is the most severe. These engineered structures include above ground pipe and equipment supports. Expansion joints in pipes supported by a structure must allow for movement similar to the movement of the structure. Lastly, the pipe system is designed to withstand transient hydraulic conditions that may occur because of an earthquake. This could include power loss to a pump station, which would shut down the pumps to create the transient condition (Carollo Engineers 2004). Because of the construction considerations and standard design requirements described above, impacts associated with seismic hazards are not considered significant.

### *Mineral Resources*

No project elements are located within designated MRZ-1 or MRZ-2 zones. The South Coast Materials Company quarries and San Luis Rey River and associated MRZ zones are not situated within the project footprint. There would not be impacts to the known aggregate resources associated with the quarry.

The proposed offsite project elements are located within MRZ-3 zones (DOC 1996). Also, the majority of offsite project element sites have not been delineated as an important mineral resource recovery site within the general plans of the applicable cities, and no impacts would result for these alignments. Mineral resources within the City of Carlsbad are no longer being extracted and utilized as exploitable natural resources (City of Carlsbad 1994).

One portion of the green alignment along College Boulevard which would traverse the MRZ-2 site associated with the South Coast Materials Company Carlsbad Quarry (immediately south of SR78/College Boulevard intersection in the City of Oceanside). However, in the vicinity of the MRZ-2 quarry area, the proposed alignment would be located within existing College Boulevard or be located just east of the alignment (*Figure3-5*). As such, it is not anticipated that exploitable mineral resources would be affected given the developed nature of the roadway. For these reasons, impacts to mineral resources would be less than significant.

## 4.5.5 Mitigation Measures

**4.5-1** To provide a uniform bearing for the proposed facility, the fill/residual soils beneath the desalination facility site shall be removed and recompacted. As an alternative, all the building footings may be deepened through the compacted fill soils and be founded into the formational materials of the Santiago Formation, in accordance with the recommendations contained in the geotechnical report (GeoLogic Associates 2004).

**4.5-2** A pre-construction geotechnical investigation shall be prepared to address geotechnical considerations related to constructing and operating all of the offsite project components including water delivery pipelines, the pump station, and surge control facilities. The report shall contain all necessary requirements to address any adverse soils conditions that may be encountered in final design of the facilities. The project will be required to adhere to all such requirements. The report shall include a discussion of site-specific geology, soils and foundational issues, a seismic hazards analysis to determine the potential for strong ground acceleration and ground shaking, potential groundwater issues, and structural design recommendations. The soil engineer and engineering geologist shall review the grading plans prior to finalization to verify the plans' compliance with the recommendations of the report. A third party review of the geotechnical report and final grading plans shall be conducted by the Engineering Department of the appropriate local jurisdiction (e.g., the City of Carlsbad) prior to issuance of grading permits and encroachment permits. Compliance with this measure shall be verified by the local jurisdiction.

### 4.5.6 Level of Significance After Mitigation

With the incorporation of mitigation measures identified in *Section 4.5.5* above, all impacts related to geology, soils and seismicity would be reduced to a less than significant level.