4.4 GEOLOGY AND SOILS

4.4.1 Existing Setting

4.4.1.1 Regional Geology and Soils

The Master Plan study area is a 1-mile wide corridor along 58 river miles of the San Gabriel River in southern California, from its headwaters in the Angeles National Forest to its terminus at the Pacific Ocean between Long Beach in Los Angeles County and Seal Beach in Orange County. The project area travels through three regions with different geological characteristics (Upper San Gabriel River Watershed, San Gabriel Basin, and Los Angeles Coastal Plain), which are discussed below. Soil types in the Master Plan study area are shown in **Figure 4.4-1**.

The Concept Design Study site for the San Gabriel Canyon Spreading Grounds is located in the San Gabriel Basin region. The Woodland Duck Farm, San Gabriel River Discovery Center, and Lario Creek project sites are located on the border between the San Gabriel Basin and Los Angeles Coastal Plain regions. The Concept Design Study site for El Dorado Regional Park is located in the Los Angeles Coastal Plain region.

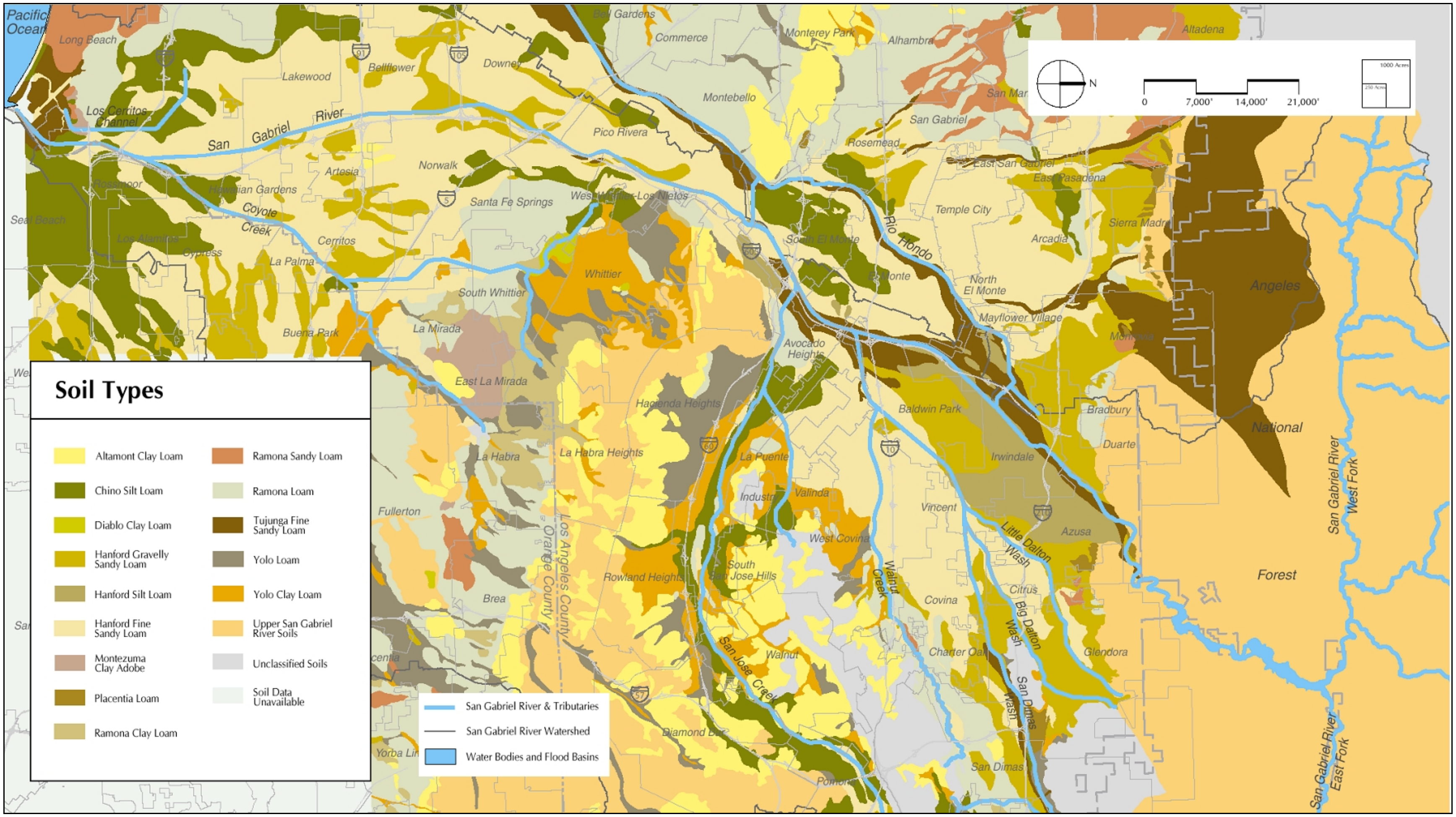
Upper San Gabriel River Watershed

The Upper San Gabriel River Watershed, located within the Angeles National Forest in the San Gabriel Mountains, begins at the headwaters of the San Gabriel River and ends approximately at San Gabriel Canyon Road in Azusa. The San Gabriel Mountains are part of the Transverse Ranges, which are steep mountain slopes formed by rapid tectonic uplift resulting from the collision of two tectonic plates estimated to have started over 6 million years ago. Elevations in the San Gabriel Mountains range from 900 feet above mean sea level (msl) along their base to over 10,000 feet above msl.

Geology of the San Gabriel Mountains is mostly Mesozoic (65 to 245 million years ago) granitic rocks, but there are also Precambrian (544 to 4,600 million years ago) igneous and metamorphic rock complexes. There are also occasional Pleistocene (57.8 to 65 million years ago) non-marine sedimentary deposits adjacent to the riverbed.

The primary native soil types in the San Gabriel Mountains are silt loam and sand (SCAG, 2004).

Figure 4.4-1
Master Plan Study Area Soils Map



Source: LADPW and RMC.

San Gabriel Basin

The San Gabriel Basin region begins approximately at the San Gabriel Canyon Road in Azusa and extends south to Whittier Narrows, which is a low point between the Puente Hills and Merced Hills, which forms the southern boundary of the San Gabriel Valley.

The geology in the San Gabriel Basin is dominated by unconsolidated to semi-consolidated alluvium deposited by streams flowing out of the San Gabriel Mountains. These deposits include Pleistocene and Holocene (10,000 years ago to the present) alluvium and the lower Pleistocene San Pedro Formation (CDWR, 1966). The Upper Pleistocene alluvium deposits form alluvial fans along the San Gabriel Mountains. The San Pedro Formation is characterized by its interbedded marine sand, gravel, and silt (CDWR, 1966).

The San Gabriel Basin is an unconfined aquifer (i.e., the groundwater is not separated from the ground surface by an impermeable geological boundary) (CSPUP, 2000). The porous alluvium, which can be hundreds of feet in depth, provides a highly permeable connection between the surface and the aquifer. The result is that much of the river flows underground southward from the mountains below the valley and forms the San Gabriel Valley Groundwater Basin (CSPUP, 2002). The alluvium forms most of the productive water-bearing zones, but the San Pedro Formation also bears fresh water.

The primary native soil types in the San Gabriel Basin area are sandy loam, silt loam, and clay loam (SCAG, 2004).

Los Angeles Coastal Plain

The Los Angeles Coastal Plain region extends from the Whittier Narrows to the Pacific Ocean. The geology of the Los Angeles Coastal Plain ranges from Pleistocene- to Holocene-aged alluvium deposited from the San Gabriel River to marine sediments deposited during periodic encroachment of the sea. These sediments are grouped in four different formations: recent alluvium, the Lakewood Formation, the San Pedro Formation, and the Pico Formation.

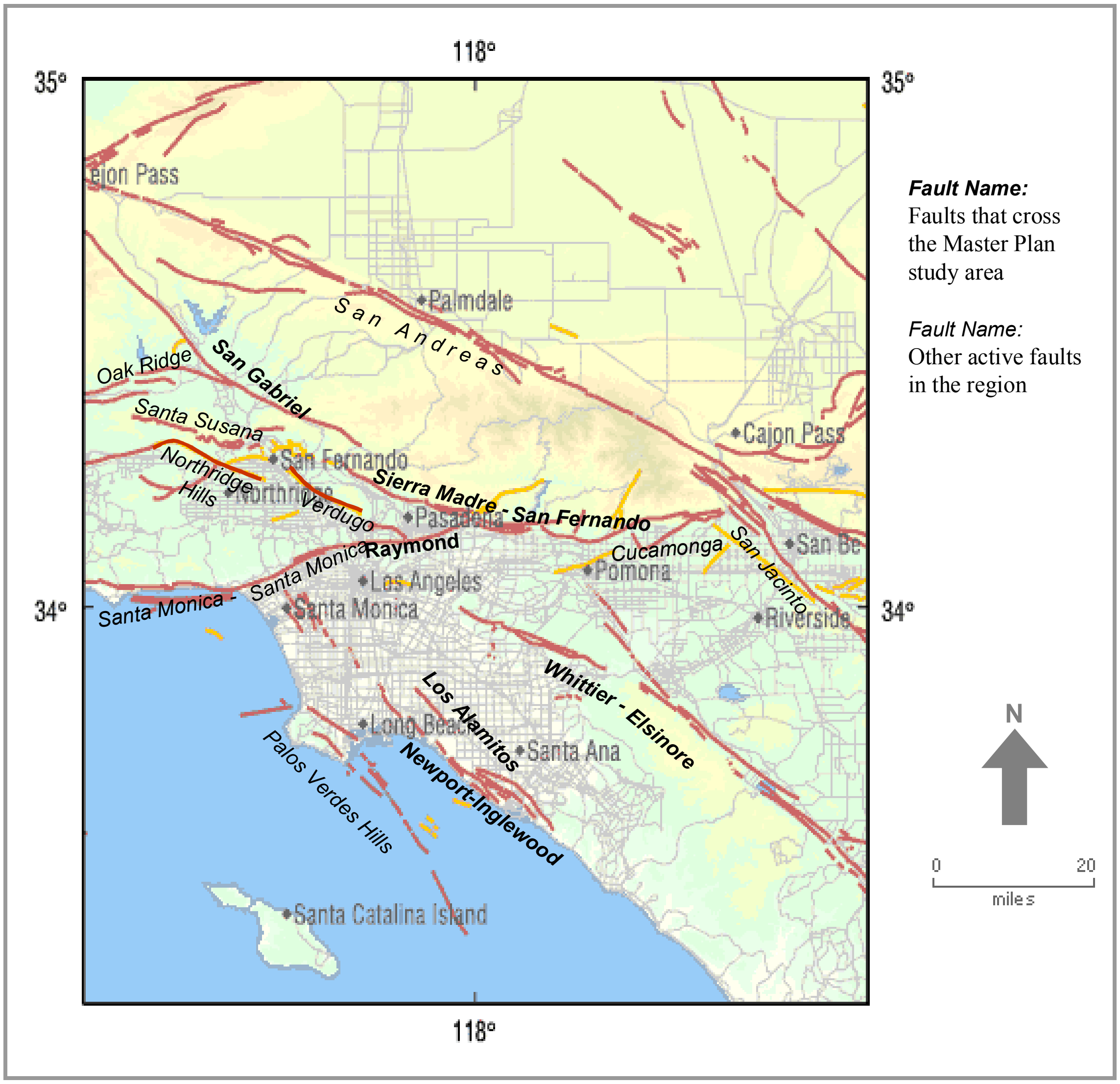
The Los Angeles Coastal Plain is divided into two groundwater basins, the Central Basin and the West Basin. The Newport-Inglewood Uplift and a confining unit of clay and silt divide these two basins. The basins were formed by folding of consolidated sedimentary, igneous, and metamorphic rocks that underlie the basins at great depths. These groundwater basins consist of permeable sands and gravels separated by semi-permeable to impermeable sandy clay to clay soils that extend to about 2,200 feet below ground surface (CDWR, 1961).

The primary native soil type in the Los Angeles Coastal Plain is sandy loam (SCAG, 2004).

4.4.1.2 Faults

The Master Plan study area is penetrated by several faults, including the Newport-Inglewood, Los Alamitos, Whittier-Elsinore, Raymond, Sierra Madre-San Fernando, and San Gabriel (See **Figure 4.4-2**). Fault lines gave rise to the formation of the east and west forks of the San Gabriel River. The surface flow of the river cut its course to the ocean before the uplift occurred that resulted in the formation of the Puente and Montebello Hills. Geologists believe that the river then eroded these formations to form the Whittier Narrows before continuing its course to the ocean again. Fault information is taken primarily from the Southern California Earthquake Data Center (SCEDC, 2004).

Figure 4.4-2
Regional Fault Map



Source: USGS, 2003.

San Gabriel Fault

The San Gabriel fault trends northwest-southeast through the San Gabriel Mountains and is approximately 87 miles in length. The fault is comprised of a series east-west trending faults with a right-lateral strike-slip and with a dip steep to the north. The most recent surface rupture was in the Holocene Epoch. Estimated slip rate is 1 to 5 millimeters per year (mm/yr). There are no estimations on the maximum credible magnitude of future earthquakes, but the recurrence interval varies per fault section and is likely to be more active on the western portions of the fault.

Sierra Madre-San Fernando Fault

The Sierra Madre-San Fernando fault trends along the front of the San Gabriel Mountains. The fault is made of five separate reverse faults measuring approximately 9 miles per section and 47 miles total. It has recently been suggested that a large event on the San Andreas fault to the north could cause simultaneous ruptures on reverse faults south of the San Gabriel Mountains. The most recent surface rupture was in the Holocene Epoch. Estimated slip rate is between 0.36 and 4 mm/yr. Interval between surface ruptures is estimated to be several thousand years. Its estimated probable Magnitude is between 6 and 7.

Raymond Fault

The Raymond fault is an east-northeast trending, left-lateral fault with minor reverse slip. The structure forms the western boundary of the San Gabriel Basin with the Raymond Groundwater Basin. The fault has a slip rate between 0.10 and 0.22 mm/yr. This fault extends a total of 16.2 miles. The most recent surface rupture was during the Holocene Epoch. The most recent major earthquake associated with this fault was the Pasadena Earthquake of 1988, which occurred at a depth 9.6 miles below ground with a 5.0 magnitude. The interval between major ruptures is estimated to be 4,500 years.

Whittier-Elsinore Fault

The Whittier-Elsinore fault is a right-lateral strike-slip fault with a northeastern dip and an estimated slip rate between 2.5 and 3.0 mm/yr. Its estimated length is 25 miles. The most recent surface rupture occurred in the Holocene Epoch. Historical activity has been limited to microseismicity and several Magnitude 4 or less events. The Whittier-Elsinore fault is considered capable of producing an earthquake with a magnitude between 6.0 and 7.2.

Los Alamitos Fault

The Los Alamitos fault is indistinct and considered by some as part of another fault system, possibly the Compton-Los Alamitos fault. The fault is located near the Lakewood, Bellflower, and Los Alamitos communities and extends 6.8 miles. The most recent surface rupture occurred in the Late Quaternary Period.

Newport-Inglewood Fault

The Newport-Inglewood Fault is a right-lateral strike-slip fault with a slip rate of 0.6 mm/yr. The total length of the fault is approximately 47 miles. This fault is associated with the Long Beach Earthquake of 1933, which had a magnitude of 6.4. Its probable magnitude is between 6.0 and 7.4.

4.4.1.3 Seismic Ground Shaking and Surface Rupture

Seismic Ground Shaking. The greatest concentration of historical, local seismic events has resulted from activity on the Newport-Inglewood Fault (related to recent activity), the Whittier Fault (1987 Whittier Narrows earthquake), the Sierra Madre Fault (1971 San Fernando earthquake), and the Raymond Fault (1988 Pasadena earthquake).

Ground motion or shaking caused by an earthquake is commonly measured as a percentage of the force of gravity, or %g. The force of gravity (g) is equivalent to an acceleration of 9.78 meters per second^2. The peak acceleration is the largest acceleration recorded by a particular station during an earthquake. The maximum credible peak acceleration (the percent probability of ground motion hazard in the area) with a 10 percent probability of exceedance in 50 years is between 60 and 80 %g for the Master Plan study area (USGS, 1996).

Surface Rupture. Surface rupture occurs when movement on a fault deep within the earth breaks through to the surface. Fault rupture usually follows preexisting faults, which are zones of weakness. Rupture may occur suddenly during an earthquake or slowly in the form of fault creep. Sudden displacements are more damaging to structures because they are accompanied by shaking.

The Alquist-Priolo Earthquake Fault Zoning Act is a California law passed in 1972 to prevent the construction of buildings used for human occupancy on the surface trace of active faults. The Alquist-Priolo Act only addresses the hazard of surface fault ruptures and is not directed toward other earthquake hazards. The law requires the State Geologist to establish regulatory zones (known as Earthquake Fault Zones) around the surface traces of active faults and to issue appropriate maps. The maps are distributed to all affected cities, counties, and state agencies for their use in planning and controlling new or renewed construction (California Geological Survey, 2002a). According to the California Geological Survey (2002b), all five Concept Design Study sites are located outside of the Alquist-Priolo Earthquake Fault Zones. Within the overall Master Plan study area, the coastal area along the Newport-Inglewood Fault is the only area that could potentially contain active fault traces within an Alquist-Priolo Earthquake Fault Zone.

4.4.1.4 Landslides / Slope Instability

Landslides involve the downslope movement of masses of soil and rock material under gravity. There is a broad range of landslide morphology, rates, patterns of movement, and scale. Landslides can be caused by ground shaking, such as earthquakes, or heavy precipitation events. Surface ground failure could also be associated with subsurface slope failure adjacent to a river or wash, as the stream undercuts the adjacent bank. The risk of this type of failure increases during seismic events. Unstable conditions are also increased by a lack of vegetation cover.

Since the San Gabriel Mountains are essentially shattered from extensive faulting, the mountains and hillsides in the northern portion of the Master Plan study area are vulnerable to landslides, undercutting by streams and heavy debris flows. According to the State of California Department of Conservation Seismic Hazard Mapping Program (CDOC, 1999), the following areas within the Master Plan study area are considered to be landslide hazard zones: the San

Gabriel Mountains, the Puente Hills area east of the Whittier Narrows and south of State Route 60, and the sideslopes of several gravel mines located in Irwindale. None of the Concept Design Study sites are located within landslide hazard zones.

4.4.1.5 Liquefaction

Liquefaction is a process by which sediments below the water table temporarily lose strength and behave as a liquid rather than a solid. In the liquefied condition, soil may deform enough to cause damage to buildings and other structures. Seismic shaking is the most common cause of liquefaction. Liquefaction occurs in sands and silts in areas with high groundwater levels.

Liquefaction has been most abundant in areas where groundwater occurs within 30 feet of the ground surface. Few instances of liquefaction have occurred in areas with groundwater deeper than 60 feet (EERI, 1994). Dense soils, including well-compacted fills, have low susceptibility to liquefaction (EERI, 1994). According to the CDOC (1999), the San Gabriel Canyon area and the area along the San Gabriel River from Baldwin Park to the ocean are considered susceptible to liquefaction based on historical occurrence of liquefaction or local geological and groundwater conditions. All five Concept Design Study sites are located in areas identified to be susceptible to liquefaction.

4.4.1.6 Expansive Soils

Expansive soils are soils that swell when they absorb water and shrink as they dry. Pure clay soils and claystone are good examples of expansive soils. Typically, soils that exhibit expansive characteristics comprise the upper 5 feet of the surface (SCAG, 2004). The hazard associated with expansive soils is that structural damage may occur when buildings are placed on these soils. Foundations rise during the wet periods and fall during the dry periods. Different parts of a building may rise and fall at varying rates and cause foundation cracking. Various structural portions of a building may become distorted so that doors and windows do not function properly. Locations of expansive soils are site-specific. Potential impacts due to presence of expansive soils can generally be remedied through standard engineering practices (SCAG, 2004).

4.4.1.7 Subsidence

Land subsidence is the loss of surface elevation due to the removal of subsurface support. Land subsidence is caused by a variety of activities that contribute to the loss of support materials within a geologic formation. For example, agricultural practices can cause oxidation and subsequent compaction and settlement of organic clay soils or hydro-compaction allowing land elevations to lower or sink. Land subsidence can also result from overdraft of an aquifer (i.e., groundwater pumping in exceedance of the rate of aquifer replenishment). The extraction of mineral or oil resources can also cause subsidence. Adverse effects associated with subsidence include lowering of the land surfaces, increased potential for flooding, disturbance or damage to buried pipelines and associated structures, and damage to structures.

Within the Master Plan study area, subsidence is known to occur in the following areas: along the coast (Long Beach area), the area northeast of the intersection of Interstate 5 and 605 freeways, and the Whittier Narrows area (SCAG, 2004).

4.4.1.8 Soil Erosion

Soil erosion is the process whereby soil materials are worn away and transported to another area by either wind or water. Rates of erosion can vary depending on the soil material, structure, and placement by human activity. The erosion potential for soils is variable throughout the project area. Soil containing high amounts of silt can be easily erodible while sandy soils are less susceptible. Excessive soil erosion can eventually lead to damage of building foundations, roadways and dam embankments. Erosion is most likely on sloped areas with exposed soil, especially where unnatural slopes are created by cut and fill activities.

4.4.2 Significance Criteria

Project impacts related to geology and soils would be considered significant if the project:

- Exposes people or structures to risk of substantial damage, loss, injury, or death involving:
  - Rupture of a known earthquake fault
  - Strong seismic ground shaking
  - Seismic-related ground failure, including liquefaction
  - Landslides / slope instability
  - Expansive soils
  - Subsidence
- Results in substantial soil erosion or the loss of topsoil

4.4.3 Impacts of Adopting the Master Plan Elements

The Master Plan includes six plan elements (also called Master Plan goals), set forth as the CEQA project objectives for the Master Plan. The plan elements are supported by objectives and performance criteria (see **Section 3.3.1**). The adoption of the Master Plan by the County of Los Angeles (and other municipalities in the study area) will promote implementation of projects that are consistent with these Master Plan goals. This section describes the overall Master Plan impacts based on a qualitative assessment of reasonably foreseeable effects of the adoption of the Master Plan. Since projects similar to the Concept Design Studies are proposed throughout the river corridor, the Concept Design Study impacts (**Section 4.4.4**) further illustrate the types of potential impacts expected from implementation of the overall Master Plan.

As described below in **Table 4.4-1**, adoption of the Master Plan could result in both beneficial and potentially adverse impacts. Primary adverse impacts related to geology and soils are temporary increases in soil erosion potential during construction of facilities and potential increases in liquefaction risk from stormwater infiltration. These impacts would be addressed in second-tier CEQA documentation for future projects developed in a manner consistent with the Master Plan (see **Section 4.4.5**). Since mitigation will reduce these impacts to less than significant levels (see **Table 4.4-1** and **Section 4.4.5**), the overall impacts related to geology and soils from adopting the Master Plan are considered less than significant. Site-specific mitigation measures will be identified and implemented by the specific lead agencies for each future project in the Master Plan study area.

Table 4.4-1
Impacts on Geology and Soils from Adopting the Master Plan Elements

Master Plan Elements	Impacts on Geology and Soils	Impact Summary
Habitat Element: Preserve and enhance habitat systems through public education, connectivity and balance with other uses	**Beneficial:** Preservation of existing habitat areas would prevent development of habitable structures on open space areas subject to seismic related hazards. Habitat restoration efforts that include planting vegetation would serve to stabilize project site soils and reduce erosion. **Neutral:** This element also includes objectives and performance criteria that are neutral with respect to impacts on geology and soils (e.g., establishment of habitat area design standards and identification of indicator species). **Potentially Adverse:** Habitat enhancement that involves active restoration in undeveloped areas (e.g., extensive removal of existing vegetation and replanting with high-value, native vegetation) could result in ground disturbance, which would result in temporary increase in soil erosion potential. Preparation of SWPPPs including implementation of standard erosion control measures that would contain sediment on-site and minimize sedimentation to adjacent waterways would reduce impacts to less than significant levels (**Section 4.6.5**).	Potentially significant for construction-related soil disturbance; less than significant with mitigation Less than significant for project operation
Recreation Element: Encourage and enhance safe and diverse recreation systems, while providing for expansion, equitable and sufficient access, balance and multi-purpose uses	**Beneficial:** Preservation of existing open space areas for passive recreational uses would prevent development of habitable structures in areas subject to seismic related hazards. Development of park space that includes planting vegetation would serve to stabilize project site soils and reduce erosion. **Neutral:** This element also includes objectives and performance criteria that are neutral with respect to impacts related to geology and soils (e.g., educating the public about catch and release fishing, establishing design standards for trails). **Potentially Adverse:** Adoption of this element may result in projects that involve construction of recreation related habitable structures (e.g., interpretive centers and park buildings). The design of such structures would be required by law to conform to the latest versions of the uniform building code and possibly relevant municipal codes. Building codes include minimum design standards for structural seismic resistance to reduce the risk of life loss or injury in the event of an earthquake. Adherence to these regulations would minimize potential seismic impacts to the proposed structures. This impact would be less than significant.	Potentially significant for construction-related soil disturbance; less than significant with mitigation Less than significant for project operation

Master Plan Elements	Impacts on Geology and Soils	Impact Summary
	Construction of recreation related facilities (e.g., interpretive centers, trails and trail amenities, signs, kiosks) on an undeveloped site would result in ground disturbance, which would result in temporary increase in soil erosion potential. Preparation of SWPPPs including implementation of standard erosion control measures that would contain sediment on-site and minimize sedimentation to adjacent waterways would reduce impacts to less than significant levels (**Section 4.6.5**).	
Open Space Element: Enhance and protect open space systems through conservation, aesthetics, connectivity, stewardship, and multi-purpose uses.	**Beneficial:** Preservation of existing open space areas would prevent development of habitable structures on open space areas subject to seismic related hazards. Enhancement of open space that includes planting vegetation would serve to stabilize project site soils and reduce erosion. **Neutral:** This element also includes objectives and performance criteria that are neutral with respect to impacts on geology and soils (e.g., use of drought tolerant and native plants).	Beneficial (no adverse impact)
Flood Protection Element: Maintain flood protection and existing water and other rights while enhancing flood management activities through the integration with recreation, open space and habitat systems.	**Neutral:** This element includes objectives and performance criteria that are neutral with respect to impacts on geology and soils (e.g., coordination of maintenance of flood protection system with habitat needs). **Potentially Adverse:** Flood control related facilities (e.g., storm drains) could be damaged during an earthquake and may need to be repaired. Failure of storm drains and underground tanks could result in release of water to the immediate vicinity, but would not create dangerous conditions to nearby residences since the structures would be buried. Since failure of these structures would not result in substantial risk to people or properties, this impact is less than significant. Construction of new flood control facilities (e.g., stormwater detention areas) on an undeveloped site would result in ground disturbance, which would result in temporary increase in soil erosion potential. Preparation of SWPPPs including implementation of standard erosion control measures that would contain sediment on-site and minimize sedimentation to adjacent waterways would reduce impacts to less than significant levels (**Section 4.6.5**).	Potentially significant for construction -related soil disturbance; less than significant with mitigation Less than significant for project operation
Water Supply and Water Quality Element: Maintain existing water and other rights while enhancing water quality, water supply, groundwater recharge, and water conservation through the integration with recreation, open space and habitat systems.	**Potentially Adverse:** Adoption of this element would encourage construction of stormwater treatment wetlands and other facilities that are designed to allow infiltration to the groundwater. As described in further detail in **Section 4.4.4.3**, if groundwater levels rise within 30 feet of the surface from project infiltration, this could result in increased risk of liquefaction. Prior to construction of facilities that involve infiltration, a geotechnical investigation will be conducted to define site-specific subsurface conditions and evaluate the potential for increase in liquefaction risk. If the project is determined to have the potential to cause groundwater levels to rise within 30 feet of the surface, monitoring and	Potentially significant for construction -related soil disturbance; less than significant with mitigation Less than

Master Plan Elements	Impacts on Geology and Soils	Impact Summary
	contingency measures would be required as described in Mitigation Measure MP-G1 to reduce liquefaction-related impacts to a less-than-significant level. Ground disturbance during construction of facilities designed to increase water supply or improve water quality could result in temporary increase in soil erosion potential. Preparation of SWPPPs including implementation of standard erosion control measures that would contain sediment on-site and minimize sedimentation to adjacent waterways would reduce impacts to less than significant levels (**Section 4.6.5**).	significant for project operation
Economic Development Element: Pursue economic development opportunities derived from and compatible with the natural aesthetic and environmental qualities of the river.	**Neutral:** This element includes objectives and performance criteria that are neutral with respect to impacts on geology and soils (e.g., providing incentives to participating adjacent landowners). **Potentially Adverse:** This element promotes the pursuit of economic development opportunities which consider connectivity to the river corridor and establishment of development standards. Adoption of this element could encourage reclamation of gravel mines. Sideslopes of gravel mines are potentially susceptible to landslides in the event of an earthquake or heavy precipitation. An evaluation of slope stability conducted as part of the geotechnical analyses during design of gravel mine reclamation projects would ensure that proposed modification does not result in unstable slope conditions (see also **Section 4.4.5.2**).	Potentially significant; less than significant with mitigation

4.4.4 Impacts of Implementing the Concept Design Studies

4.4.4.1 Seismic Ground Shaking and Surface Rupture

As with the rest of southern California, the Master Plan study area is located in a seismically active region. In general, future projects implemented in the Master Plan study area would be subject to ground shaking during a seismic event. As described in **Section 4.4.1.5**, many active faults occur within the area, and future Master Plan project sites could be affected by surface ruptures if movement occurred along a fault underlying the site.

Projects without Habitable Structures. The Concept Design Studies for the San Gabriel Canyon Spreading Grounds, Woodland Duck Farm, Lario Creek, and El Dorado Regional Park do not involve construction of habitable structures. However, these projects may include construction or installation of other structures/facilities such as trails, signage, gateways, constructed wetlands, and structures for storage or conveyance of stormwater or reclaimed water (e.g., retention basins, underground pipes, and pump stations). While these structures could be damaged during an earthquake and may need to be repaired, they would not pose substantial risks to people or properties. Failure of storm drains and underground tanks could result in release of water to the immediate vicinity, but would not create dangerous conditions to nearby residences since the structures would be buried. Since failure of these structures would not result in substantial risk to people or properties, this impact is less than significant.

Projects with Habitable Structures. The Concept Design Study for the San Gabriel River Discovery Center includes construction of a habitable structure (the Discovery Center building). Other future projects may also involve construction of habitable structures such as park buildings or education centers. The design of such structures would be required by law to conform to the latest versions of the uniform building code and possibly relevant municipal codes. Building codes include minimum design standards for structural seismic resistance to reduce the risk of life loss or injury in the event of an earthquake. Adherence to these regulations would minimize potential seismic impacts to the proposed structures. This impact would be less than significant.

4.4.4.2 Landslides / Slope Instability

As described in **Section 4.4.1.4**, there are three major areas within the Master Plan study area with potential for landslide hazards: the San Gabriel Mountains, the Puente Hills east of the Whittier Narrows and south of State Route 60, and the sideslopes of several gravel mines located in Irwindale. The five Concept Design Study sites are not located within landslide hazard zones or in hillside areas. It is anticipated that future projects located within these hazard areas would be designed with necessary slope stabilizing measures. Therefore, impacts related to landslides and slope stability are considered less than significant.

4.4.4.3 Liquefaction

Due to the presence of loose alluvium materials deposited by the San Gabriel River, most of the Master Plan study area falls within the liquefaction hazard zone (see **Section 4.4.1.5**). All five Concept Design Study sites are located in areas considered by the California Geological Survey to be susceptible to liquefaction based on historical occurrence of liquefaction or local geological and groundwater conditions.

The Master Plan Concept Design Studies for the Woodland Duck Farm, Lario Creek, San Gabriel River Discovery Center, and El Dorado Regional Park include constructed wetlands, which may be unlined and designed to allow infiltration to the groundwater. Additionally, other future projects may include groundwater recharge of stormwater (e.g., at former gravel pits). If project-related stormwater infiltration caused groundwater levels to rise within 30 feet of the surface, the project could result in an increased risk of liquefaction. In addition to the long-term effects of stormwater infiltration on groundwater levels, large volumes of stormwater infiltrated over a short period of time could have a temporary “mounding” effect, causing a localized increase in the groundwater level beneath the infiltration basins. If stormwater infiltration at the Concept Design Study sites resulted in a substantial increase in groundwater levels and consequently increased liquefaction risk for onsite or adjacent habitable or other structures (e.g., power line towers, bridges, and flood control facilities), the impact would be significant. Incorporation of **Mitigation Measure CD-G1** (conduct groundwater monitoring and cease infiltration if necessary to prevent groundwater levels from increasing to within 30 feet of the surface) would reduce project impacts related to liquefaction to a less-than-significant level.

The Lario Creek Concept Design Study would also facilitate transfer of additional water to existing spreading basins for groundwater recharge. Since the volume of water to be infiltrated is within the existing capacity of the spreading basins, impacts related to this component of the Concept Design Study are considered less than significant.

4.4.4.4 Expansive Soils

Master Plan Concept Design Studies for the Woodland Duck Farm and El Dorado Regional Park and other future projects may involve construction of stormwater infiltration facilities near power line towers. Project-related infiltration would likely alter the moisture content of the soils in the immediate vicinity of the infiltration areas. If infiltration facilities were sited in close proximity to the power line towers and if these structures were located on expansive soils, the change in soil moisture content from the infiltration could result in damage to these structures, a potentially significant impact. Incorporation of **Mitigation Measure CD-P10** (see **Section 4.9.6 – Public Services and Utilities**) would reduce this impact to a less-than-significant level.

The Concept Design Study for the San Gabriel River Discovery Center includes construction of a habitable structure (the Discovery Center building). Other future projects may also involve construction of habitable structures such as park buildings or education centers. If habitable structures were constructed on expansive soils, the potential damage to these structures would be considered a significant impact. Incorporation of **Mitigation Measure CD-G2** (site-specific review of soil conditions and, if necessary, replacement or treatment of expansive soils to minimize risk of structural damage) would reduce this impact to a less-than-significant level.

4.4.4.5 Subsidence

The Master Plan Concept Design Studies for the Woodland Duck Farm, Lario Creek, the San Gabriel River Center, and El Dorado Regional Park include constructed wetlands, which may be unlined and designed to allow infiltration to the groundwater. Additionally, other future projects may include groundwater recharge of stormwater (e.g., at former gravel pits). These projects could involve minor groundwater withdrawal for groundwater quality monitoring. However, the amount required would be a negligible fraction of existing groundwater extractions in the area and would be offset by the proposed infiltration of stormwater, which would overall result in a beneficial impact with respect to subsidence. Therefore, the proposed project is not expected to result in subsidence. No impacts would occur.

4.4.4.6 Soil Erosion

Soil disturbance associated with project construction will increase the potential for wind and water erosion in the immediate vicinity of the facilities. As required by the Environmental Protection Agency and the Los Angeles Regional Water Quality Control Board, the construction contractor(s) will develop and implement a Stormwater Pollution Prevention Plan (SWPPP) during construction of various project components. This plan is required as part of the federal Clean Water Act National Pollution Discharge Elimination System (NPDES) Permit for discharge of stormwater associated with construction activities greater than 1 acre in area. Incorporation of stormwater best management practices in the SWPPP would reduce the potential for soil erosion during construction. Specific erosion control measures to be considered for inclusion in site-specific SWPPPs are listed in **Section 4.6 – Water Quality**. Therefore, with the incorporation of control measures in the SWPPPs, construction impacts on soil erosion are expected to be less than significant.

Once construction is complete, disturbed surfaces at each project site would be stabilized (i.e., paved or revegetated). All five Concept Design Study sites currently include unimproved surfaces that are prone to soil erosion. Implementation of each of the Concept Design Studies would likely reduce the soil erosion potential at these sites by increasing the vegetative cover. Therefore, the project is expected to have a beneficial impact with respect to soil erosion once construction has been completed (no adverse impact).

4.4.5 Master Plan Program Mitigation Measures

4.4.5.1 Liquefaction

As described above in **Section 4.4.1.5**, most of the Master Plan study area falls within a liquefaction hazard zone. Future projects that would result in increased infiltration of stormwater will require an evaluation of the increase in liquefaction potential. Future projects that would result in increased infiltration (including but not limited to construction of stormwater retention/infiltration facilities, unlined wetlands, and structures designed to increase in-stream recharge (e.g., rubber dams)) will require an evaluation of the impacts of the proposed actions on liquefaction potential as described in program Mitigation Measure MP-G1:

> **MP-G1** During facility design, a site-specific geotechnical analysis will be conducted to determine soil types and groundwater levels. Based on the results of the geotechnical analysis, the potential increase in liquefaction potential from the proposed infiltration will be evaluated. Factors that will be considered include the capacity of the infiltration facility and the associated amount of water proposed for infiltration, infiltration rate, proximity and types of nearby structures that could be damaged from liquefaction, and infiltration at adjacent spreading grounds, if any.
>
> If the project is determined to have the potential to cause groundwater levels to rise within 30 feet of the surface, new monitoring wells and/or existing wells in the project area will be used to detect any substantial increase in groundwater levels. If monitoring indicates a substantial rise in groundwater levels that could impact adjacent structures, stormwater would not be infiltrated and would be diverted into storm drains or onto street surfaces or routed to other stormwater management facilities as applicable.

4.4.5.2 Landslides / Slope Instability

Sideslopes of gravel mines are potentially susceptible to landslides in the event of an earthquake or heavy precipitation. Future projects that involve reclamation of gravel mines to create parks, open space and/or stormwater retention facilities will require an evaluation of the impacts of proposed actions related to landslides and slope instability as described in program Mitigation Measure MP-G2:

> **MP-G2** Site-specific evaluation of slope stability will be conducted as a part of the geotechnical analyses during design of each future Master Plan project that involves

modification of a gravel mine. The recommendations of the geotechnical study will include optimum slope design for stability and safety, soil compaction or recompaction requirements, surface cover, and potentially other slope stabilizing measures. The recommendations of the geotechnical analysis will be incorporated into the detailed design of the project. The results of site-specific evaluations and detailed mitigation measures, if any, will be disclosed in subsequent CEQA documentation.

4.4.5.3 Habitable Structures

For future projects that include construction of habitable structures (e.g., recreation or interpretive centers), an evaluation of the impacts of proposed actions related to geologic hazards will be required as described in program Mitigation Measure MP-G3:

MP-G3 The site plan and building footprint will be reviewed by a registered professional to ensure that project siting and design provides adequate protection from geologic hazards such as fault rupture (including Alquist-Priolo Earthquake Fault Zones), expansive soils, liquefaction, and unstable slopes. If a project site is located in known high risk areas with respect to geological hazards, a site-specific geotechnical study will be performed during facility design to identify potential concerns and recommended measures to reduce hazards. Recommendations in the geotechnical study will be incorporated into the final design.

4.4.6 Mitigation Measures for Concept Design Studies

Liquefaction

The following mitigation measure shall be implemented for the **Woodland Duck Farm, San Gabriel River Discovery Center, Lario Creek, and El Dorado Regional Park** Concept Design Studies:

CD-G1 Prior to construction, conduct a geotechnical investigation to define site-specific subsurface conditions, including determination of site-specific groundwater levels and soil conditions to evaluate the potential for liquefaction onsite or at adjacent properties. Based on the results of the geotechnical analysis, the potential increase in liquefaction potential from the proposed infiltration shall be evaluated. Factors that should be considered include the capacity of the infiltration facility and the associated amount of water proposed for infiltration, infiltration rate, proximity and types of nearby structures that could be damaged from liquefaction, and infiltration at adjacent spreading grounds, if any.

If the project is determined to have the potential to cause groundwater levels to rise within 30 feet of the surface, new monitoring wells and/or existing wells in the project area shall be used to detect any substantial increase in groundwater levels. If monitoring indicates a substantial rise in groundwater levels that could impact adjacent structures, stormwater would not be infiltrated and would be diverted into storm drains or onto street surfaces with sufficient capacity.

Soil Erosion

Section 4.6 – Hydrology and Water Quality lists possible erosion control measures to be incorporated into site-specific SWPPPs. Measures to reduce fugitive dust generated during construction (see **Section 4.1 – Air Quality**) will also minimize the potential for wind erosion of soils.

Expansive Soils

The following mitigation measure shall be implemented for the **San Gabriel River Discovery Center** Concept Design Study:

CD-G2 During facility design, evaluate site soils to determine the area and thickness of expansive soils. If expansive soils are found, one or more of the following measures shall be specified in the construction plans to minimize potential hazards associated with expansive soils:

- Replacement of expansive soils with granular non-expansive soils, or
- Treatment of expansive soils with lime to reduce expansivity, or
- Other appropriate geotechnical practices.

These measures that mitigate for expansive soils shall be incorporated into the construction documents.