

3.6 Geology and Soils

This section describes the existing geology and soils in the Study Area and presents a summary description of the regulatory setting. This section also evaluates the potential for the proposed Project to expose people or structures to potential seismic-related impacts, result in soil erosion or the loss of topsoil, or occur within unstable soils. The proposed Project would result in potentially significant adverse effects to people or structures associated with earthquake fault rupture, strong seismic ground shaking, seismic-related ground failure, or landslides and impacts from being located on geology or soil that is unstable that could result in landslides, lateral spreading, subsidence, liquefaction, or collapse. However, with the implementation of standard construction design regulations and mitigation measures proposed as part of the proposed Project, impacts would be reduced to a less-than-significant level.

3.6.1 Physical Environmental Setting – Geology and Soils

Geology

The Study Area is located within the County of Los Angeles in the northwest portion of the San Gabriel Valley. The San Gabriel Valley within the vicinity of PWP's service area is characterized as having sharp contrasts in terrain. This portion of the valley contains a steeply rising range of the San Gabriel Mountains in the north, highlands referred to as the San Rafael Hills on the west, and a series of east-trending knolls along the south. Elevations in PWP's service area range from about 560 feet above mean sea level at the southernmost point, to about 1,280 feet near the point where the Arroyo Seco emerges from the San Gabriel Mountains.

Soils

Soils within the San Gabriel Valley are composed of sediment that was shed during the emergence of the San Gabriel Mountains. As such, the San Gabriel Valley contains alluvial fan sediments composed of unconsolidated gravel, sand, silt, and clay. The uppermost layer of alluvium is generally defined as a loose to medium dense silty-sand that is underlain by discontinuous beds of moderately dense sand and gravelly sand (Amec 2010).

Seismicity, Landslides and Liquefaction

A review of the State of California's Seismic Hazard Zones Map (California Geological Survey [(CGS) 1999] shows the Raymond Fault immediately south of PWP's service area and within two miles of facilities proposed as part of the Southern Extension (see **Figure 3.6-1**). The eastern and central sections of the Raymond Fault and portions of the Verdugo Fault are designated Alquist-Priolo Earthquake Fault Zones by the CGS. These sections of the Raymond and Verdugo faults are located adjacent to PWP's southern service area within the Mt. Wilson Quadrangle and the Los Angeles Quadrangle, but are not located within the Study Area. There are no fault zones in the Study Area that are designated by the Alquist-Priolo Earthquake Fault Zoning Act. The San Gabriel Fault, Eagle Rock Fault, Verdugo Fault Zone, Hollywood Fault Zone, Whittier Fault Zone,

Elysian Park Fault Zone, Scholl Canyon Fault, and other inferred or otherwise unnamed fault zones are within or adjacent to PWP's service area and the portion of the City of Glendale containing the Scholl Canyon Reservoir and a portion of the proposed Phase I Project pipelines. In addition, the San Andreas Fault is located approximately 21 miles northeast of PWP's service area.

Several areas in Study Area have been identified as vulnerable to earthquake-induced landslides and liquefaction within the Seismic Hazard Zone Map (see **Figure 3.6-1**). The mountainous region along the northern reaches of the City is susceptible to slope failure due to the steep terrain. The crystalline bedrock that crops out in the northern and central portions of the San Rafael Hills is highly fractured and weathered. In steep areas, strong ground-shaking can cause slides or rock falls of this material. Slope failures can also occur in the southwestern portion of the City, where steep terrain is combined with weak sedimentary rock units. Numerous small landslides can be expected to occur in these areas in response to an earthquake on the Sierra Madre or other nearby faults. Over-steepened slopes along the large drainage channels, such as the Arroyo Seco, are also locally susceptible (Amec 2010). The ridges around Scholl Canyon have also been identified as vulnerable to earthquake-induced landslides, primarily on the ridge faces away from the canyon (CGS 1999).

Due to the proximity of PWP's service area to active fault zones, PWP conducted a *Preliminary Geological Feasibility Study* to assess potential hazards associated with seismicity, liquefaction, and landslides within the proposed Phase I alignment in October 2010. Bedrock in potential excavation sites of the Study Area was found to be rippable, shallow slope failures did not extend beneath existing access road cuts, and larger landslides were located in areas such that they would not affect the proposed Project. Earthquakes were found to be likely to occur, due to the Phase I Project's location near the Raymond, Verdugo, and Sierra Madre faults. Of the alternative alignments investigated in the Study, the northern alignment was found to be more likely to experience landsliding than that southern; as a result, the southern alignment was selected for the proposed Project. Finally, one portion of the Phase I Project may be susceptible to liquefaction, in the alluvial floor of the Arroyo Seco, which would be crossed by the pipeline. However, the Study found that design choices could reduce the risks posed by potential liquefaction and that construction in this area was not a fatal design flaw. The Study found that the southern alignment and the storage tank proposed for the Phase I Project are both sited in geotechnically and seismically feasible locations (Amec 2010).

Impact Statements and Mitigation Discussions

This section discusses potential impacts related to geology and soils that could result from implementation of the proposed Project. Mitigation measures are identified where appropriate.

Impact 3.6-1 Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of known earthquake fault, strong seismic ground shaking, seismic-related ground failure, including liquefaction, or landslides.

Project Level Review of Phase I Project

The Phase I Project would be partially constructed in a recognized seismic hazard zone including a known earthquake fault, risk of strong seismic ground shaking, and liquefaction. The Technical Background Report for the Safety Element of the City of Pasadena's General Plan shows there is a possible active strand of the Sierra Madre Fault that runs east-west along the northern portion of the City of Pasadena. This possible fault strand extends from Allen Avenue just north of Washington Boulevard west to approximately Fair Oak Avenue. The possible fault line also jogs north to approximately Idaho Street. From there, the possible fault runs west to approximately Chevy Chase Canyon Drive, in the City of Glendale (City of Pasadena 2002). The Phase I Project would primarily lie south of this possible fault, though the tunnel water transmission pipelines, the Sheldon Non-Potable Water Reservoir site, and associated appurtenances all either cross the potential fault or are located within the Fault Hazard Management Zone. Despite this potential active fault, the *Preliminary Geological Feasibility Study*, found that the Phase I Project was not within an area of recognized active faulting, that there were no Special Study Zones within the Pasadena Quadrangle, and there was no indication of active faulting during site reconnaissance (AMEC 2010). Supporting the finding of the preliminary feasibility study, the City of Pasadena's Natural Hazards Mitigation Plan does not discuss faults that lie within the proposed Study Area (City of Pasadena 2004).

The Safety Element of the City of Glendale's General Plan shows two branches of the Scholl Canyon fault run through Scholl Canyon near the portion of the Phase I Project within the City of Glendale, including near the proposed Scholl Canyon non-potable reservoir. This fault runs generally east-west from approximately the border between the City of Glendale and the City of Pasadena to the east, and Verdugo Road to the west. The Scholl Canyon Fault is not a designated Alquist-Priolo Earthquake Fault Zone, nor is it in a Fault Hazard Management Zone. Other nearby faults include the Sycamore Canyon fault north of the Glendale portion of the Study Area, Verdugo Fault west of the Glendale portion of the Study Area, and Eagle Rock Fault south of the Glendale portion of the Study Area (Glendale 2003).

The *Preliminary Geological Feasibility Study* also found the potential for fault rupture of the ground surface along the proposed Phase I Project alignments to be minimal. However, this study indicated that due to proximity of the Study Area to active faults, the Phase I Project would likely experience strong ground motions as a result of a moderate to large earthquake on nearby or distant active faults. Based on the recommendation of

the study, design of the proposed non-potable water reservoirs in the Phase I Project should consider potential effects associated with earthquake ground motions.

The *Preliminary Geological Feasibility Study* found the alluvial floor of Arroyo Seco within the western portion of PWP's service area is listed as susceptible to liquefaction within the Seismic Hazard Zone Map. Portions of pipeline for the Phase I Project would cross the Arroyo Seco, and it is possible these pipelines could be impacted by seismically-induced settlement due to liquefaction. The Study indicated design of pipelines within this area could incorporate flexible pipe joints, which would reduce the potential for damage due to seismically-induced settlement. The City of Pasadena Water Department Seismic Criteria Document indicates pipelines that cross known liquefiable areas should be designed using the procedures established within the American Lifelines Alliance (ALA) *Seismic Guidelines for Water Pipelines* (ALA 2005). The Phase I Project would adhere to the seismic guidelines set by the City of Pasadena, thereby implementing design criteria that reduce the potential for pipelines to be adversely impacted by seismically-induced settlement.

The *Preliminary Geological Feasibility Study* also found a large portion of the steep natural terrain in proximity to the Phase I Project may be susceptible to seismically induced landslides and identified several existing landslides within PWP's service area. However, aerial photograph analysis and reconnaissance mapping conducted for the study found no definitive evidence of seismically induced landsliding at the Scholl Canyon Non-potable Water Reservoir site or along pipeline alignments proposed as part of the Phase I Project. As such, the study concluded the potential for seismically-induced landsliding for the Phase I Project is low.

Design of the proposed Phase I facilities would conform to the standards specified in the City of Pasadena Water Department Seismic Criteria Document, which also incorporates applicable building codes and specifications and industry standard procedures, and addresses specific design criteria related to potential landslide areas. Because the Phase I Project would conform to the City of Pasadena Water Department Seismic Criteria Document, implementation would not expose people or structures to potential adverse effects relating to strong seismic ground shaking, or seismic-related ground failure (i.e., liquefaction, or landslides). Impacts would be less than significant and no mitigation is required.

Program-Level Review of Future Extensions

Portions of the Future Extensions' facilities would be in proximity to the Raymond Fault and Verdugo Fault, which are located within a Fault Hazard Management Zone (Amec 2010). However, as no facilities are sited within a fault zone, no facilities would be subject to potential fault rupture.

Similar to the Phase I Project described above, due to proximity of the Study Area to active faults, the proposed facilities under the Future Extensions would likely experience strong ground motions as a result of a moderate to large earthquake on nearby or distant active faults. Strong ground shaking could affect the integrity of the proposed facilities.

The *Preliminary Geological Feasibility Study* found the floor of Arroyo Seco within the western portion of PWP's service area is listed as susceptible to liquefaction within the Seismic Hazard Zone Map. In addition, the Seismic Hazard Zone Map shows that the southern portion of the Study Area, which would include the Annandale Extension, Southern Extension I, Southern Extension II, and Northwestern Extension, would be susceptible to liquefaction (CGS 1999). Portions of the Study Area are also located within a "Liquefaction Hazard Zone" identified within the Safety Element of the City of Pasadena General Plan (City of Pasadena 2002).

As noted above, the *Preliminary Geological Feasibility Study* found several existing landslides within PWP's service area. The Safety Element of the City of Pasadena General Plan contains a Seismic Hazards Map, which denotes areas where previous occurrence of landslide movement or local topographic, geological, geotechnical, and groundwater conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code §2693 would be required (City of Pasadena 2002). Portions of land within proximity to facilities that are part of the proposed Future Extensions are located within these known or potential seismic hazard areas, as defined by the City of Pasadena.

Although design of the facilities would conform to the standards specified in the City of Pasadena Water Department Seismic Criteria Document, a site specific geological evaluation must be conducted prior to construction of facilities for the Future Extensions, specifically the Annandale Extension, Southern Extension I, Southern Extension II, and Northwestern Extension segments, which are in areas identified in the Seismic Hazard Zone Map as susceptible to liquefaction. Investigations, provisions, and engineering specifications set forth in the *Preliminary Geological Feasibility Study* prepared for the proposed Project adhere to standards set forth within the City of Pasadena's Hillside Excavation and Grading Ordinance (Pasadena Municipal Code Chapter 14.05). With the incorporation of Mitigation Measure 3.6-1, in conjunction with applicable design standards for the City of Pasadena, the Future Extensions would not expose people or structures to potential substantial adverse effects relating to seismic-related ground failure. Impacts would be less than significant after mitigation.

Significance Determination Before Mitigation

Potentially significant

Mitigation Measures

The following mitigation measure is applicable to the Southern Extension I, Southern Extension II, and Northwestern Extension segments of the Future Extensions.

Mitigation Measure 3.6-1: Prepare Geological Report for Potentially Affected Facilities. During the design phase for the Non-Potable Water Project Future Extensions, PWP will require preparation of a Geologic Report by a geologist registered in the State of California for facilities proposed for the proposed Project that have not been previously analyzed and could potentially be located within known seismic hazard zones shown on **Figure 3.6-1**.

The Geologic Report will include an engineering analysis of liquefaction and slope stability for the distribution pipelines, pump stations, storage facilities, and pressure reducing station within the PWP service area. This assessment will include a liquefaction assessment study in accordance with the California Geological Survey Special Publication 117 Guidelines, and the Southern California Earthquake Center's procedures to implement Special Publication 117. If this report finds unstable soils would present potential risks associated with liquefaction or landslides, engineering recommendations for surface and subsurface drainage specifications and detailed design for fill placement and excavation will be provided and incorporated into design of the proposed Project.



Significance Determination After Mitigation

Less than significant

Impact 3.6-2 Potential to result in substantial soil erosion or loss of topsoil.

Project-Level Review of Phase I Project

Construction activities associated with the Phase I Project are anticipated to disturb at least 1.0 acre of soil. Thus, construction of the Phase I Project would be required to comply with the Construction General Permit (Order No. 2009-0009-DWQ), which is issued by the SWRCB (refer also to *Section 3.9 Hydrology and Water Quality*). The Construction General Permit requires development of a SWPPP, which outlines BMPs the discharger would use to reduce erosion and topsoil loss from storm water runoff. Compliance with the Construction General Permit would ensure construction of facilities follows mandated BMPs, and therefore would not result in substantial soil erosion or the loss of topsoil. Impacts are considered less than significant and no mitigation is required.

Program-Level Review of Future Extensions

Construction activities associated with the proposed Future Extensions could involve excavation and earthmoving, which could expose soils to erosion-related processes. This disturbance of the ground surface could facilitate erosion of the soil materials during construction, which could in turn lead to accumulation of soil materials within localized drainages. Construction activities would disturb more than 1.0 acre of soil for each extension. As such, construction of the proposed Future Extensions would be required to comply with the Construction General Permit as described for the Phase I Project above. Compliance with the Construction General Permit would ensure construction of proposed Future Extensions' facilities follows mandated BMPs, and therefore does not result in substantial soil erosion or the loss of topsoil. Impacts are less than significant and no mitigation is required.

Significance Determination Before Mitigation

Less than significant

Mitigation Measures

No mitigation is required

Impact 3.6-3 Project 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.

Project-Level Review of Phase I Project

The Phase I Project extends across an alluvial plain, which has potential for liquefaction, collapse, and expansion (City of Pasadena 2004). As described above, seismic ground shaking can trigger liquefaction or differential settlement. Liquefaction zones mapped by the CGS indicate there is liquefaction hazard within proximity to facilities proposed under the Phase I Project (CGS 1999). In addition, proposed facilities for the Phase I Project are located near and cross the Arroyo Seco drainage channel, which suggests these facilities may be susceptible to the effects of collapsible soils (City of Pasadena 2002). Although the *Preliminary Geological Feasibility Study* concluded the potential for seismically-induced landsliding for the Phase I Project is low (Amec 2010), construction of Phase I Project facilities within proximity to unstable soils could potentially expose people or structures to substantial adverse effects.

The Phase I Project would adhere to standards set forth within the City of Pasadena Water Department Seismic Criteria Document (G&E 2006). This document addresses specific design criteria related to potential landslide areas, and provides guidelines to reduce potential impacts in potential landslide areas to a less than significant level. The Phase I Project would adhere to seismic-related guidelines set by the City of Pasadena, and would implement design criteria that reduce the potential for facilities to experience on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse. Therefore, impacts are less than significant and no mitigation is required.

Program-Level Review of Future Extensions

The City of Pasadena rests primarily on an alluvial plain composed of unconsolidated gravel, sand, silt, and clay, which has potential for liquefaction, collapse, and expansion (City of Pasadena 2004). As described above, seismic ground shaking can trigger liquefaction or differential settlement. Liquefaction zones mapped by the CGS indicate there is liquefaction hazard within proximity to facilities proposed under the Future Extensions (CGS 1999). Additionally, the *Preliminary Geological Feasibility Study* found several existing landslides within PWP's service area (Amec 2010). Construction of proposed Future Extensions' facilities within proximity to these unstable soils could potentially expose people or structures to substantial adverse effects.

The final design of these facilities would be in conformance with the City of Pasadena Water Department Seismic Criteria Document (G&E 2006). By adhering to seismic-related guidelines set by the City of Pasadena, the proposed Future Extensions would

implement design criteria to reduce the potential for pipelines and other facilities to be adversely impacted by landslides, lateral spreading, subsidence, liquefaction, or collapse as a result of unstable soil. Coupled with implementation of **Mitigation Measure 3.6-1** (above), application of seismic design standards would be sufficient to prevent significant damage to the proposed facilities if landslides or other impacts associated with collapsible soils. With implementation of the proposed mitigation, this impact would be reduced to less than significant.

Significance Determination Before Mitigation

Potentially significant

Mitigation Measures

See **Mitigation Measure 3.6-1** above. This mitigation measure is applicable to the Southern Extension I, Southern Extension II, and Northwestern Extension segments of the Future Extensions.

Significance Determination After Mitigation

Less than significant

Impact 3.6-4 Project is located on expansive soil, potentially creating substantial risks to life or property.

Project-Level Review of Phase I Project

The majority of PWP's service area contains alluvial soils that are primarily granular in nature, and therefore have a low to moderately low expansion potential (City of Pasadena 2002). However, the Study Area also contains sedimentary units with layers of fine-grained soils such as clays and silty clays that have moderate to high expansion potential (City of Pasadena 2002). The latter types of soils (potentially expansive soils) are more common within the southern portion of PWP's service area on the edges of alluvial fans (City of Pasadena 2002). Construction activities associated with the Phase I Project would not be located within the southern portion of PWP's service area where potentially expansive soils are known to exist (City of Pasadena 2002). However, expansive soils may not be present at the surface and may be exposed during excavation or grading.

Expansive soils are not anticipated to be encountered during the Phase I Project. Pipelines would be constructed outside any expansive layers that are uncovered during excavation. No other structures in the Phase I Project would be constructed on expansive soils. Impacts associated with expansive soils are less than significant and no mitigation is required.

Program-Level Review of Future Extensions

Potentially expansive soils are more common within the southern portion of PWP's service area on the edges of alluvial fans (City of Pasadena 2002). Expansive soils may also be present near the San Rafael Hills within PWP's service area, but outside of the