

## 5.4 GEOLOGY AND SOILS

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### SUMMARY

*The impact analysis presented in this section evaluates project impacts related to geologic hazards. The geotechnical analyses prepared for the project concluded that the project site is suitable for the proposed uses from a geotechnical perspective. As the uses proposed by the project are built out, site-specific geotechnical studies would be conducted to assure that no impact would occur as buildout on the site occurs. Mitigation measures are recommended which would reduce project impacts associated with unstable and expansive soils to a less than significant level.*

### INTRODUCTION

This section summarizes the geotechnical studies and corresponding reports that were prepared for the proposed project. Refer to **Appendix 5.4** for the following geotechnical reports:

- Allan E. Seward Engineering Geology, Inc. Geologic and Geotechnical Report, *EIR-Level Review of Preliminary Grading Plan for the Master's College Master Plan*. 2007
- Allan E. Seward Engineering Geology, Inc. Geologic and Geotechnical Report; *Engineering Geology and Geotechnical Review*. 2007).
- Gorian Associates, Inc., *Preliminary Grading Plan Review, The Master's College, Santa Clarita, California*. 2007.
- Gorian Associates, Inc. *Preliminary Geotechnical Investigation, The Master's College, Santa Clarita, California*. 2005.

These reports summarize findings regarding existing geology, existing surficial deposits, potentially significant geologic and surficial impacts, and recommended mitigation measures for these impacts.

### EXISTING CONDITIONS

#### Regional Geology

The City of Santa Clarita is located in the Transverse Range Geomorphic Province of California, which is characterized by east-west trending mountains and faults. Sedimentary basins within the Transverse Range Geomorphic Province include the Ventura, Soledad, and Ridge Basins, and the San Fernando Valley. The Ventura, Soledad, and Ridge Basins are the result of the interplay of the San Andreas Fault and the Transverse Range fault systems. Seismic activity along the San Andreas Fault is in response to differential movement between the Pacific geologic plate (west of the fault) and the North American geologic plate (east of the fault). Transverse Range faults generally reflect crustal (reverse) faults.

The project site is in the eastern portion of the Ventura Basin, which is separated from the Soledad Basin and the Ridge Basin by the active San Gabriel fault zone. This fault zone traverses the area in a northwest-southeast trend approximately 9,000 feet to the north of the site. The Ventura Basin was subsequently filled with sediments eroding from the adjacent uplifted bedrock blocks, which form the surrounding mountains. These sediments, which consist primarily of sand and gravel, contain abundant granitic and volcanic rocks suggesting a source in the San Gabriel and Santa Susana Mountains. The Saugus Formation is a continental deposit overlying marine Pico Formation of Pliocene age and overlain by upper Pleistocene deposits of the ancestral Santa Clara River including the Pacoima Formation.<sup>1</sup>

The area of the proposed 54-unit condominium development is located on the generally southeast-northwest trending bedrock hillside areas and at the toe of the hillside on both northern and southern sides. The hillside areas are moderately steep rolling bedrock ridges and ridge spurs with slope gradients ranging from approximately 2:1 (h:v) on the sides of the hillside to nearly level on the top of the ridges. The hillside areas are covered with a moderate to dense growth of seasonal weeds and grasses with scattered patches of native shrubbery.

## **Geomorphology**

The site topography is dominated by a west to northwesterly trending ridge, with minor canyon spurs and swales that descend to its western terminus at Newhall Creek. South of the ridgeline, the site topography descends to Newhall Creek adjacent to the southwest project boundary. North of the ridgeline, the site topography descends to the alluvial valley floor of Placerita Canyon. Slope gradients in the hillside areas of the site are moderate with an average gradient of about 2:1 (h:v). Ground surface elevations range from about 1,275 feet at the westernmost portion of the site to about 1,530 feet at a high point along the existing ridgeline at the easternmost portion of the site.

## **Geologic Units**

The project site is underlain by bedrock of the Quaternary-age Pacoima Formation (Qp) mantling bedrock of the Plio-Pleistocene-age Saugus Formation (TQs). Soil units on the property include relatively thin mantles of Quaternary-age alluvium (Qal), Quaternary-age stream channel deposits (Qsc), artificial fill (af), and both topsoil and colluvium.

All of the proposed project area is situated in an area marginally susceptible to debris flow. In other words, evidence of debris-flow activity is uncommon but may occur locally.

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<sup>1</sup> South Coast Geological Society (1982).

Bedrock of the Plio-Pleistocene-age Saugus Formation underlies the Pacoima Formation to the maximum depth explored. The Saugus Formation is commonly exposed on the southern side of the subject hillside area and in the northeastern portion of the site where not covered with the draping Pacoima Formation. The Saugus Formation represents paleo-Santa Clara River floodplain deposits and adjacent interfingering tributary and alluvial fan sediments.

### ***Saugus Formation (TQs)***

The Saugus Formation generally consists of yellowish brown silty to clayey fine- to coarse-grained sandstone units. Locally, the sandstone is interbedded with yellowish brown clayey siltstone to sandy siltstone and reddish brown to yellowish brown mudstone (mudstone consists of particles one-third sand, one-third silt and one-third clay) to sandy claystone in a damp to moist condition.

Saugus Formation is inclined to the north-northwest at moderate angles (12 degrees to 16 degrees after CDMG, 1987) to low angles (2 degrees to 10 degrees). The Saugus Formation is crudely bedded to locally well defined, but typically exhibits gradational contacts. Some of the beds can be correlated across the project site while others appear to be interfingering and grade laterally. The top of the Saugus Formation at the base of the Pacoima Formation is commonly a distinct erosional surface. The top of the Saugus Formation appears to be a poorly developed paleosol consisting of reddish brown grading to yellowish brown mudstone with manganese oxide staining to sandy claystone to locally yellowish brown clayey to silty fine- to coarse-grained sandstone to cemented sandy to clayey siltstone.

### ***Pacoima Formation (Qp)***

Bedrock of the Quaternary-age Pacoima Formation mantles the majority of the upper reaches of the generally northwest-southeast trending ridge and drapes over the hillside on the northern side of the project site to the toe of the hillside. This formation has been designated as Older Dissected Surficial Sediments (Qog); however, these high terrace deposits of sand and gravel have been assigned to the Pacoima Formation.

The Pacoima Formation was found to vary in thickness from 5 feet to more than 70.5 feet . The bedrock generally consists of light yellowish brown to yellowish brown to brown silty to clayey fine- to coarse-grained sandstone with some gravel, cobbles, and rare boulders in a damp to moist and commonly friable condition. Locally, the sandstone is interbedded with yellowish brown clayey siltstone to sandy claystone in a moist to very moist condition. Clasts incorporated in this formation generally consist of subangular to well-rounded metavolcanics, granitics, and quartzite. The sandstone units are locally crossbedded and locally have magnetite laminations. Bedding is generally crude to locally well defined.

The Pacoima Formation represents a period of basin filling with sediments derived from the erosion of the Santa Susana Mountains and northern sources, interfingering with sediments derived from the paleo-Santa Clara River.

Structurally, the Pacoima Formation rests unconformably on the underlying Saugus Formation, however, locally appears to be conformable where both bedrock units are nearly horizontal. Geologic data indicate that the bedrock is generally inclined in a northerly direction at low angles (0 degrees to 10 degrees), although some variation and fluctuation in bedding was noted with bedding inclined in a southerly and easterly direction also at low angles (3 degrees to 7 degrees). The base of this formation is usually a sharp yet irregular erosional contact that is nearly horizontal on the top of the ridges and inclined in a northerly direction at low to moderate angles (6 degrees to 14 degrees) where the bedrock drapes over the hillside to the north.

### ***Alluvium (Qal)***

Quaternary-age alluvium typically fills the bottom of the valley floors and portions of the incised drainages. These water-transported materials are easily visible in the Newhall Creek area and locally on the site where erosion has exposed these deposits. Alluvium was found to vary in thickness from 17.5 feet to 34 feet. The alluvium in the incised drainages on the southern side of the hillside and was found to vary in thickness from 1.5 feet to 8.5 feet.

The alluvium on the northern side of the hillside area generally consists of dark gray silty fine sand in a damp and loose condition grading downward to yellowish brown clayey fine to coarse sand with some gravel and cobbles in a damp and dense condition. The lower portion of the alluvium generally consists of light yellowish brown silty fine to coarse sand with gravel in a slightly moist and dense condition.

The alluvium on the southern side of the site adjacent to Newhall Creek generally consists of very dark grayish brown to brown grading to yellowish brown fine sand to silty sand to gravelly sand in a damp to moist and loose to very dense condition locally interstratified with dark reddish brown to brown sandy to clayey silt in a damp and hard condition.

Alluvium encountered from the hillsides and in drainages consists of brown silty fine to coarse sand in a porous, damp, and loose condition overlying brown to yellowish brown clayey fine to coarse sand with gravel to boulders in a damp and medium dense condition yet porous with pores to 0.125 inch. Typically, the base of the alluvium is defined with a cobble to boulder lag deposit and a sharp erosional contact with the underlying bedrock.

### ***Stream Channel Deposits (Qsc)***

Soil deposits in the active Newhall Creek are referred to as stream channel deposits. These deposits generally consist of sand and gravel in a damp and loose condition. These materials are similar to alluvium; however, the stream channel deposits have been reworked during periods of heavy runoff. These deposits are not within any area of the proposed construction.

### ***Colluvium (Slopewash)***

Soils that have been deposited under the influence of gravity are referred to as colluvium. Colluvium is commonly deposited down slope faces and in incised ravines. Colluvium was encountered in an incised ravine that was subsequently covered with artificial fill. The colluvium was found to be on the order of 3.5 feet in thickness and consisted of very dark grayish brown clayey sand with some gravel and cobbles in a moist and medium dense condition. The contact with the underlying bedrock is gradational over 12 inches.

### ***Topsoil***

Topsoil generated from the in place weathering of the bedrock materials typically mantles the bedrock materials. The topsoil on site is on the order of 1 to 1.5 feet in thickness and generally consists of brown silty fine to coarse sand with some gravel and cobbles in a damp and medium dense condition. Seasonal weeds and grasses typically extend their root systems through the topsoil materials.

### ***Artificial Fill (af)***

Artificial fill associated with construction of the existing college campus is generally confined to the northern side of the hillside in close proximity to the existing buildings and access roadways. Artificial fill was in an area currently used to dispose of soils and construction debris within the college property. The artificial fill here was found to be 2.5 feet in thickness and generally consists of dark gray silty fine to coarse sand with some concrete and asphaltic concrete debris in a damp and loose condition.

Additional artificial fill deposits were encountered in the northeastern corner of the playfield on the southern side of the hillside. This playfield was manufactured as a result of permanent required fill to an elevation of 1,325 feet during the construction of the Placerita Tunnel based on a review of plans and profiles provided by the Metropolitan Water District (MWD). The current elevation of the playfield ranges from elevation 1,325 feet to 1,330 feet, so it is possible that some minor artificial fill has been placed over the fills made by MWD. The artificial fill was found to be on the order of 5 feet in thickness and generally consists of brown clayey to silty fine to coarse sand with some gravel and cobbles in a

damp and medium dense condition. Maximum depth of fill within the playfield area based on MWD plans is approximately 35 feet.

Additional artificial fill deposits (previously engineered fill) are located in the southeastern portion of the site in association with the development of the adjacent residential Tract 53114. A fill slope on the order of 100 feet in height aligned at a 2:1 (h:v) with a maximum depth of approximately 50 feet descends off site from Lots 1–5, Tract 53114 to the valley floor.

## **Groundwater**

Regional groundwater maps indicate that the project site is located within an area where the alluvial aquifer is deeper than 100 feet beneath the alluvial surface. However, Los Angeles County water well data indicates that historic high ground water was measured about 26 feet below the ground surface at Water Well No. 5872A, just south of the intersection of 4<sup>th</sup> Street and Newhall Creek, within the Master's College property boundary.

Groundwater was encountered on site at 17 to 52 feet below the existing ground surface. Typically, groundwater seepage on site was confined to silty fine to coarse-grained sandstone units that are underlain by fine-grained materials such as claystone (mudstone) and siltstone. No other groundwater was observed on the site. No surface water was observed flowing in the adjacent Newhall Creek during an on-site reconnaissance.

## **Seismicity**

The project site is located in the seismically active southern California region. Earthquake-related hazards typically include ground rupture, ground shaking, and ground failure. Faults identified as active or potentially active in published geologic literature are not known to be present within or adjacent to the subject site. Recent field exploration revealed no indication of active or potentially active faults. However, the project site is situated in the seismically active Transverse Ranges and can be expected to experience strong ground shaking from earthquakes generated on active regional faults, as evidenced by the strong ground shaking generated by the January 17, 1994, Northridge earthquake (magnitude 6.7).

### ***Ground Rupture and Shaking***

The project site is located in southern California, which is an active seismic area where large numbers of earthquakes are recorded each year. The project site and vicinity experienced strong ground motion during the 1971 San Fernando earthquake (which was generated by the Sierra Madre–San Fernando fault), and more recently during the 1994 Northridge earthquake. **Table 5.4-1, Significant Historical**

**Earthquakes Near Project Site**, summarizes significant historical earthquakes that have occurred near the site.

**Table 5.4-1**  
**Significant Historical Earthquakes Near Project Site**

Earthquake	Site-to-Epicenter Distance (Miles)	Earthquake Magnitude	Date
Fort Tejon	96	7.9	1857
Kern City	51	7.7	1952
Santa Barbara	74	7.0	1812
San Fernando	7.0	6.6	1971
Northridge	11.6	6.7	1994

*Source: Southern California Earthquake Center. 2000.*

The seismic moment determines the energy that can be radiated by an earthquake and hence the seismogram recorded by a seismograph. The moment magnitude of an earthquake is defined relative to the seismic moment for that event.

The following active faults are near the project site:

**San Gabriel Fault.** The San Gabriel Fault is an active fault that crosses the City. This fault is a long break that extends from near Fraser Mountain, to near the Tejon Pass, near the City of San Bernardino. The fault has had right lateral strike-slip displacement and is capable of generating a maximum moment magnitude of 7.0.

**Holser Fault.** The Holser Fault trends along the northern border of the Santa Clara River Valley. The exact location in the City is concealed beneath alluvium therefore it has not been determined if this fault runs through the City. The fault is east-west trending and dips to the north.

**Santa Susana Fault.** The Santa Susana Fault is an active fault located 1 mile south of the City. This fault is a reverse fault that extends from the northern edge of Simi Valley through the northern end of the San Fernando Valley.

**San Andreas Fault.** The San Andreas Fault is the dominant active fault in California. It is located northeast of the City of Santa Clarita and is the primary surface boundary between the North American and Pacific geologic plates. The fault has right lateral strike-slip displacement.

**Oak Ridge Fault** The Oak Ridge Fault is a steep south-dipping reverse fault that forms the boundary between Oak Ridge to the south and the Santa Clara River to the north.

**San Fernando Fault** The San Fernando Fault is part of the Sierra Madre–San Fernando fault system. The fault has a reverse displacement and was the source of the 1971 San Fernando (Sylmar) earthquake.

**Table 5.4-2, Significant Regional Faults**, summarizes potential earthquake sources near the site, including estimates of maximum seismic moment magnitude that are considered geologically feasible for these sources, per the State of California.<sup>2</sup>

**Table 5.4-2  
Significant Regional Faults**

<b>Fault</b>	<b>Maximum Moment Magnitude</b>	<b>Approximate Distance to Site (Miles)<sup>1</sup></b>
Santa Susana	6.6	0.0
San Gabriel	7.0	2.1
Sierra Madre–San Fernando	6.7	2.2
Holser	6.5	2.5
Northridge (East Oak Ridge)	6.9	3.4
San Andreas	7.8	20.4

Source: Allan E. Seward Engineering Geology, Inc. February 15, 2007.

<sup>1</sup> Closest distance between site and surface projection of rupture area.

The California Department of Mines and Geology defines active faults as those that have had surface displacement within Holocene time (about the last 11,000 years). Potentially active faults are ones that have had surface displacement during the last 1.6 million years; inactive faults have not had surface displacement within the last 1.6 million years.

Seismically induced ground acceleration is the shaking motion that is produced by an earthquake. Probabilistic modeling is done to predict future ground accelerations. As shown in the Seismic Shaking Hazards Map of California, the area within the City of Santa Clarita has a 10 percent probability of experiencing peak horizontal ground accelerations of 0.7 gravity (g) to 1.0g within the next 50 years.<sup>3</sup>

<sup>2</sup> Petersen, M.D., Bryant, W.A., Cramer, C.H., Cao, T., Reichle, M.S., Frankel, A.D., Lienkaemper, J.J., McCrory, P.A., and Schwartz, D.P., *Probabilistic Seismic Hazard Assessment for the State of California* (California Department of Conservation Division of Mines and Geology, 1996) Open-File Report 96-08, 33.

<sup>3</sup> City of Santa Clarita, "Safety Element," *General Plan*, (2001) S-21.



According to the deterministic analyses, the San Gabriel fault is capable of producing a magnitude 7.2 (Mw) earthquake and generating peak ground accelerations of 0.76g. The Holser Fault is believed to be capable of producing a magnitude 6.5 (Mw) earthquake with peak accelerations of 0.89g. The Santa Susan Fault is capable of a magnitude 6.7 earthquake with peak accelerations of 0.92g, while the Sierra Madre fault is capable of producing a magnitude 6.7 (Mw) earthquake and peak ground accelerations of 0.81g.

Based on the Seismic Hazard Evaluation Report for the Newhall Quadrangle published by the California Division of Mines and Geology (CDMG), the project site has a 10 percent chance in 50 years (475 year return period) of experiencing accelerations of 0.75g for alluvium conditions and 0.78g for soft rock conditions based on a predominant earthquake of magnitude 6.6 (Mw) at a distance of 2 kilometers (km) from the site.

Alquist-Priolo Earthquake Fault Zones are areas within 500 feet of a known active fault trace. The project site is not within an Alquist-Priolo Earthquake fault Zone.

Secondary earthquake hazards include liquefaction, seismically induced settlement or differential compaction, tsunami, seiches, and flooding from dam failures. Due to the elevated topography of the site, flooding, tsunami and seiches are not expected to present a risk to the site.

### ***Ground Failure***

Ground failure is a general term that refers to secondary, permanent ground deformation caused by strong earthquake shaking, including liquefaction of saturated granular deposits or fine-grained soils with low plasticity, lateral spreading, ground lurching, seismic settlement (dynamic densification) of loose, poorly consolidated materials, differential materials response, slope failure, sympathetic movement on weak bedding planes or non-causative faults, and shattered ridge effects.

Liquefaction is defined as the transformation of a granular material from a solid state to a liquefied state as a consequence of increased pore water pressure. During ground shaking, the alluvial grains are packed into a tighter configuration. Pore water is squeezed from between the grains, increasing the pore pressure. As the pore pressures increases, the load bearing strength of the material decreases. There are areas within the City of Santa Clarita that overlie unconsolidated alluvium with a high groundwater table. These areas are primarily found near the Santa Clarita River and its tributaries.

The State of California Seismic Hazard Zones map for the Newhall Quadrangle (CGS, 1998) shows that portions of the site may be susceptible to liquefaction and/or earthquake induced landslides. Most of the project site is underlain by bedrock that is not susceptible to liquefaction. Alluvium in the portions of

canyons where fill is proposed generally is dense beneath a depth of 9 feet. Ground water generally is not present in the alluvium at the subject site, although localized zones of perched water are present at depths as shallow as 17 feet.

Relatively loose granular alluvial soils that extend to depths as great as about 9 feet in portions of the tributary canyons areas where fill is proposed may be prone to dynamic densification as a result of future earthquake shaking.

### **Slope Stability**

Earthquake-induced slope failures include activation and reactivation of landslides, rock falls, debris falls, and surface failures. Localized areas of the project site have potential for earthquake induced slope instability, according to the State of California Seismic Hazard Zones Map.

### ***Landslides***

Landslides have been mapped with the City of Santa Clarita within the Newhall quadrangle. The majority of the landslides are mapped within the Saugus and Mint Formations.<sup>4</sup>

No landslides are present within or near the site. No evidence of landsliding was encountered (i.e., thick soil development, scarp, graben soils, sheared clay) during trench excavations. Furthermore, review of published references and aerial photo evaluation show no evidence of landslides within or near the project site.

### **Hydroconsolidation (Collapse) Settlement**

Rapidly buried, unsaturated, sediments such as slopewash and alluvium commonly contain extensive voids and, as a consequence, are subject to hydroconsolidation (collapse) settlement when inundated. Hydroconsolidation occurs when water enters sediments and reorients the sediment particles into a more compact arrangement with fewer and smaller voids. Structures constructed over deposits prone to hydroconsolidation settlement may experience settlement-induced distress and damage. Potential for hydroconsolidation of soil deposits can be mitigated by removal and recompaction of the collapsible deposits.

Alluvial soils on the project site may be susceptible to hydroconsolidation. The phenomenon of hydroconsolidation does not apply to the bedrock deposits that underlie most of the site.

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<sup>4</sup> City of Santa Clarita, "Safety Element," *General Plan*, (2001) S-22.

## PROJECT IMPACTS

### Significance Threshold Criteria

According to the City of Santa Clarita Environmental Guidelines, a project would have a significant effect on the environment if it would

- expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving
  - strong seismic ground shaking;
  - seismic-related ground failure, including liquefaction; and/or
  - landslides.
- result in substantial wind or water soil erosion or the loss of topsoil, either on or off site;
- 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;
- involve a change in topography or ground surface relief features;
- involve earth movement (cut and/or fill) of 10,000 cubic yards or more;
- involve development and/or grading on a slope greater than 10 percent natural grade; and/or
- cause the destruction, covering, or modification of any unique geologic or physical feature.

### Impact Analysis

The following geotechnical aspects of the proposed project were evaluated in this impact analysis.

- Dockweiler Drive would be extended in a westerly direction, necessitating cut and fill slopes to support the road. Typical cut and fill grading techniques would be utilized to construct the road grades and the associated slopes descending to the north and south of the road. Retaining walls have also been proposed to attain the proposed road grades within the proposed grading envelope.
- A large building pad (super pad) is proposed for the future expansion of The Master's College campus between Dockweiler Drive and the existing campus. An additional building pad with associated cut and fill slopes and retaining walls is proposed south of Dockweiler Drive for the future construction of 54 condominium units.
- Maximum fill slope heights aligned at 2:1 (h:v) gradients would be on the order of 160 feet with a maximum fill depth of 90 feet.

- Proposed cut slopes would also be aligned at 2:1 (h:v) gradients with a maximum height of 95 feet and a maximum cut depth of 80 feet.
- Southerly of the extension of Dockweiler Drive, 35 residential pads for a total of 54 residential units would be constructed along with the extension Deputy Jake Drive.
- Proposed construction on the Master's College campus includes the MacArthur Chapel, future classroom and administration buildings, and dormitories. Appurtenant parking, driveways and landscaping are also proposed.

Mass grading by cut and fill techniques would be used to create level building pads for the proposed improvements at a variety of grades. Earth movement is proposed to include the movement of 1.2 million cubic yards of earth.

As part of the geotechnical analyses conducted for the proposed project, three hollow-stem auger borings with depths ranging from 26.5 to 42.5 feet were conducted. Ten bucket auger borings were excavated to depths ranging from 41 to 100 feet. Finally, eight backhoe trenches were excavated ranging in depth from 4 to 11 feet.

New campus building structures or building expansions located outside of the area covered by the Preliminary Grading Plan are within areas mapped as artificial fill (af). This artificial fill overlies alluvial deposits. Geotechnical investigation would be required for the Grading Plan and/or Building Plan phases in order to characterize the artificial fill and alluvial deposits at these proposed building locations.

Buildings No. 44 and No. 2x are proposed in an area within the proposed grading envelope that was mapped as artificial fill. Geotechnical investigation would be required for the Grading Plan and/or Building Plan phases in order to characterize the artificial fill at these proposed building locations.

Proposed buildings No. 40, 41, 42, and the 54 condominium units would be located entirely within the proposed grading envelope shown on the Preliminary Grading Plan. At completion of grading, the proposed locations of these buildings would be underlain by bedrock or by compacted fill that are suitable for support of the foundations of the buildings. Buildings located over expansive soils and/or over cut/fill transition areas would need to be evaluated at the Grading Plan phase.

The proposed grading shown on the Preliminary Grading Plan encroaches into the Metropolitan Water District (MWD) easement, City, and homeowner's association (HOA) lots. The proposed encroachment includes construction of a 25-foot-high, 2:1 (h:v) fill slope that will overlie existing fill present in the MWD easement.

Several keystone walls are proposed and shown on TTM 66503 to accommodate proposed grade breaks. The keystone wall system is an engineered system comprised of concrete segmental block units, compacted backfill, geogrid reinforcement material, and interlocking fiberglass pins connecting the wall unit and the soil reinforcement. These keystone walls are described below.

- On The Master's College campus one keystone wall adjacent to the proposed campus entrance on the Dockweiler Drive extension would be approximately 250 feet in length and range in height from 1 foot to 14 feet. This keystone wall would exceed 10 feet in height for approximately 80 linear feet. The purpose of this keystone wall is to accommodate the finished grade differences between the future campus entry road to the north and future Dockweiler Drive to the south.
- A keystone wall section is proposed near the western boundary of the project site to avoid grading interference with the existing MWD Foothill Feeder Placerita Tunnel and Newhall Siphon pipeline within the 12.6-acre MWD property. The finished grade differences are a result of the tunnel access location elevation and the minimum elevations of both future Dockweiler Drive and Deputy Jake Drive. MWD has determined that this grading and keystone wall configuration is acceptable for their purposes. This wall segment would include three stepped walls ranging in length from approximately 200 feet to 300 feet, for a total of 750 linear feet. The keystone walls range in height from 1 foot to 20 feet. The keystone walls exceed 10 feet in height for approximately 460 total linear feet.
- A keystone wall section is proposed near the center of the project site south of the Deputy Jake extension to preserve multiple oak trees, including two designated Heritage Oaks Trees, which would otherwise be removed and fill grading slopes placed over the current locations. This keystone wall section accommodates the finished grade differences between the existing Heritage and other oak trees to the south and the required location and elevation of future Deputy Jake Drive to the north. This wall segment includes three stepped walls ranging in length from approximately 100 feet to 230 feet, for a total of 540 linear feet. The keystone walls range in height from 1 foot to 20 feet. The keystone walls exceed 5 feet in height for approximately 60 total linear feet.
- A keystone wall section is proposed near the eastern boundary of the project site to preserve multiple oak trees which would otherwise be removed and fill-grading slopes placed over the current locations. This keystone wall section also accommodates the finished grade differences between the existing oak trees to the south and the required location and elevation of future Deputy Jake Drive to the north. This wall segment includes three stepped walls ranging in length from approximately 130 feet to 290 feet, for a total of 660 linear feet. The keystone walls range in height from 1 foot to 20 feet. The keystone walls exceed 10 feet in height for approximately 180 total linear feet, with approximately 330 total linear feet of wall being 5 feet or less in height.
- The NCWD has existing and proposed water reservoir facilities in the southeastern portion of the project. Located southerly of future Dockweiler Drive and northerly of existing Deputy Jake Drive, there are two separate proposed keystone walls that are necessary because of the elevation differences between the NCWD water reservoir and the roadway elevation of future Dockweiler Drive. There are no design alternatives that would reduce the need for walls and eliminate the conflict between the existing NCWD reservoir and the design/safety criteria for future Dockweiler Drive. The upper wall segment would be approximately 750 feet in length. The keystone walls range in height from 1 foot to 27 feet. The keystone walls exceed 10 feet in height for approximately 260 total linear feet. The lower wall segment is located downhill of the easterly end of the upper

keystone wall and is approximately 300 feet in length. The lower keystone wall ranges in height from 1 foot to 9 feet. The lower keystone wall is approximately 9 feet in height for 240 total linear feet. Off-site views of the keystone walls will be partially blocked by the existing and proposed NCWD reservoirs for approximately 300 linear feet of the total 750 feet of length.

### ***Geologic Hazards***

**Earthquakes:** The project site is not located in a California Alquist-Priolo Earthquake Fault Special Study Zone. However, southern California is an active seismic area and the project site experienced strong ground motion during 1971 Sylmar and 1994 Northridge earthquakes. Earthquakes would be experienced in the future and impacts would be potentially significant.

The project site has a 10 percent chance in 50 years (475 year return period) of experiencing accelerations of 0.75g for alluvium conditions and 0.78g for soft rock conditions based on a predominant earthquake of magnitude 6.6 (M<sub>w</sub>) at a distance of 2 km from the site. Ground accelerations that 0.65g have the potential for moderate to heavy damage.<sup>5</sup> Construction of the proposed project would expose people and property to these hazards; therefore, impacts would be significant without mitigation.

**Landslides/Mudslides:** No existing deep-seated landslides are known to occur on the project site. No landslides are present within or near the site nor are any shown on regional geologic maps. As such, impacts from landslides are less than significant.

**Ground Failure:** Localized areas of the site have potential for earthquake-induced slope instability, according to the State of California Seismic Hazard Zones Map. Cut and fill grading proposed for the development will mitigate the hazard of earthquake-induced slope instability in almost all of these areas. The relatively small slope areas at the site that will not be graded have favorably oriented bedding conditions and are considered to be grossly stable. Impacts would be less than significant

### ***Erosion***

Large portions of the site are currently disturbed and subject to wind and water erosion during the rainy season. Minor evidence of erosion was observed in soil that mantles slopes at the project site. Bedrock at the site is expected to be less susceptible to erosion than the overlying soil material. However, fill, bedrock, and soil material at the site will be susceptible to erosion if drainage features to control sheet flow over the ground surface are not provided.

Wind and water erosion of the site would increase during construction activities. Once developed, site erosion and sedimentation would decrease substantially compared to existing conditions because the site

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<sup>5</sup> City of Santa Clarita, "Safety Element," *General Plan*, (2001) Table S-2.

would be overcovered with non-erosive surfaces, including pavement, structures, and permanent vegetation, all which would reduce the amount of exposed soil subject to wind and water erosion.

Furthermore, implementation of the existing provisions in the City's grading requirements for planting and irrigation of constructed slopes in conjunction with drainage recommendations provided in the section "Surface Drainage and Erosion Control," would provide sufficient mitigation against potential erosion within the subject site. Therefore, the project would result in a long-term decrease on-site erosion and would not permanently increase wind and water erosion of the site. As a result, project impacts would be less than significant.

### ***Unstable Earth Conditions***

**Hydroconsolidation Settlement:** Except for the dense alluvial soils in the vicinity of Boring HS-1, all alluvial soils would be removed from areas where fill is proposed on the Preliminary Grading Plan. Therefore, the risk of hydroconsolidation of alluvial soils at the site is negligible. The phenomenon of hydroconsolidation does not apply to the bedrock deposits that underlie most of the site. Impacts would be less than significant with implementation of the proposed grading plan and mitigation.

**Expansive Materials:** Soils and sediments from both Saugus and Pacoima Formations are present on site. Fine-grained units of the Saugus Formation are known to have significant expansion potentials when exposed to water. In addition, artificial fill, slopewash, and alluvium deposits present at the site may contain material with significant expansion potential. Typically, soil, slopewash (colluvium), fill, and alluvial deposits reduce in volume (shrink) by up to about 10 percent when excavated and subsequently recompacted. In contrast, Pacoima Formation and Saugus Formation bedrock typically increases in volume (bulk) by up to about 10 percent when excavated and recompacted.

Based on the above discussion, impacts would be significant. Mitigation measures are recommended below which would reduce unstable earth conditions impacts to less than significant.

**Liquefaction:** Most of the site is underlain by bedrock that is not susceptible to liquefaction. However, alluvium in the narrow tributary canyon areas in the southwestern portion of the site is designated as potentially liquefiable on the State of California Seismic Hazard Zones Map (Newhall Quadrangle, 1998). Alluvium in the portions of canyons covered by the Preliminary Grading Plan where fill is proposed generally is dense beneath a depth of 9 feet. Ground water generally is not present in the alluvium at the subject site, although localized zones of perched water are present at depths as shallow as 17 feet. Based on the preceding factors, it appears that potential for liquefaction of alluvium in the tributary canyons is low. Impacts would be less than significant.

### ***Change in Topography or Ground Surface Relief Features***

There would be topographic changes on the project site during grading operations to accommodate the proposed project.

Gradients of the proposed cut slopes shown on the Preliminary Grading Plan are 2:1 (h:v) or flatter. The tallest proposed cut slope is approximately 95 feet high.

Eight cut slopes with a height of 20 feet or more are proposed on the Preliminary Grading Plan. Cut slope CS-2 will exhibit day lighted bedding and requires a buttress. Cut slope CS-5 is partially located within an area mapped as artificial fill; this portion of cut slope CS-5 is potentially grossly unstable.

The north-facing portion of cut slope CS-6 may expose day lighted bedding planes of the Pacoima and Saugus Formations and may be grossly unstable. Also, this slope will form the side slope of a water basin.

The proposed grading will eliminate natural slopes directly adjacent to the proposed areas of development. The natural slopes that will remain after the proposed grading has been performed do not pose a hazard to the proposed development or adjacent off site properties.

Gradients of the proposed fill slopes are 2:1 (h:v) or flatter, with terrace drains every 25 vertical feet. The tallest proposed fill slope at the site is approximately 160 feet high. Based on the analysis, gross stability of this slope and of all smaller proposed fill slopes at the site, is satisfactory.

The changes on the site, however, there would be significant changes in on-site topography of ground surface relief features such that the graded site would lose the visual continuity it currently has with its surroundings. Furthermore, all proposed slopes would be constructed with grades that would be within margins of safety to avoid potential slope failure. So, while there would be a change in on-site topography and ground surface relief features, the change is not considered to be significant.

### ***Earth Movement of 10,000 Cubic Yards of Fill or More and Development and/or Grading on Slopes Greater than 10 Percent Natural Grade***

Development of the site would move 1.2 million cubic yards of earth. The grading is required for the construction of the project. Slope gradients in the hillside areas of the project site are moderate with an average gradient of about 2:1 (h:v). Ground surface elevations range from about 1,275 feet at the westernmost portion of the site to about 1,530 feet at a high point along the existing ridgeline at the easternmost portion of the site.



Areas on part of the campus that are south of the existing buildings along Placerita Canyon Road have slope gradients that are typically steeper than 15 percent. Since a portion of the project site contains slopes greater than 10-percent natural grade, impacts would be potentially significant. Grading and construction would comply with the City of Santa Clarita Building Code, recommendations given by the Project Geotechnical Engineer, and any other regulations to minimize the risk of distress and damage on structures constructed on a slope.

The 1.1 million cubic yards of earth movement exceeds the impacts threshold and therefore impacts would be considered significant without mitigation.

### ***Destruction, Covering, or Modification of Any Unique Geologic or Physical Features***

No unique geologic or physical features exist on the project site; therefore, no impact relative to this criterion would occur.

## **MITIGATION MEASURES ALREADY INCORPORATED INTO THE PROJECT**

Recommendations provided by the geotechnical engineer identified in "Geologic and Geotechnical Report; Review of Tentative Tract Map," prepared by Allan E. Seward Engineering Geology, Inc., and dated February 15, 2007, and in "Engineering Geology and Geotechnical Review," prepared by Allan E. Seward Engineering Geology, Inc., and dated May 15, 2007, shall be incorporated as standard conditions of approval for the proposed project.

Additionally, prior to issuance of a grading permit, the final tentative tract map for the proposed project shall be reviewed by a qualified geotechnical engineer. Any recommendations provided by the geotechnical engineer shall be implemented during project grading and construction.

## **MITIGATION MEASURES PROPOSED BY THIS EIR**

### **General**

**5.4-1:** The portions of the proposed project that include encroachment into the easement/property controlled by MWD for the portions of the proposed project that will include construction of a 25-foot-high, 2:1 (h:v) fill slope that will overlie existing fill shall be evaluated, including its ability to support the proposed fill slope. If the evaluation indicates that the fill slope would not be stable, the fill slope shall be redesigned to assure stability.

- 5.4-2: Design response spectra ground accelerations for the site will need to be prepared for the Building Plan phase of development.
- 5.4-3: Relatively loose granular alluvial soils that extend to depths as great as about 9 ft in portions of the tributary canyons areas where fill is proposed may be prone to dynamic densification as a result of future earthquake shaking. The potential for dynamic densification of these materials shall be mitigated by removal of the materials and then replacing them as compacted fill.
- 5.4-4: For slopes prone to earthquake-induced sliding avoidance measures shall be included such as (setbacks), removal of surficial unstable materials, laying back slopes to a flatter gradient, buttressing, and diversion and/or collection of the expected volume of slide material by means of debris basins and/or impact walls.
- 5.4-5: Stabilization, removal, or building setbacks shall be used to mitigation landslide hazard if landslides are discovered adjacent to proposed development areas. Landslides that will not affect the proposed grading concept shall be placed in designated Restricted Use Areas.
- 5.4-6: Cut slope CS-5 is partially located within an area mapped as artificial fill; this portion of cut slope CS-5 is potentially unstable. Therefore, stability of this slope shall be investigated and evaluated at the Grading Plan phase. Cut slope CS-5 is proposed adjacent to an existing building (Building No. 14, "Slight Hall"). Potential adverse effects of the slope on the existing building shall be evaluated. If the proposed cut slope would have adverse affect on the existing building, the slope shall be reconfigured use of shoring shall be used to support/protect the existing building.
- 5.4-7: The north-facing portion of cut slope CS-6 may expose day lighted bedding planes of the Pacoima and Saugus Formations and may be unstable. Also, this slope will form the side slope of a water basin. Stability of this slope shall be evaluated at the Grading Plan stage to evaluate if buttressing or stability fills are needed.
- 5.4-8: Due to the relatively low cohesion of the earth materials at the site, measures such as avoidance, stability fills, flattening of slopes to no steeper that 3:1 (h:v), seeding/planting of slopes, and use of mechanically stabilized earth slopes, to mitigate surficial stability of all cut slopes at the site shall be required.

- 5.4-9:** Slopes less than 20 feet in height that exhibit adverse conditions, such as day lighted bedding, artificial fill, fill over cut, or sliver that cut less than 10 feet horizontally to daylight, shall be mitigated using 15- to 20-foot-wide stability fills.
- 5.4-10:** Cut slopes that do not comply with the applicable agency's requirements for static loading and for pseudo-static earthquake loading shall incorporate corrective measures such as avoidance (setbacks), cutting back to a shallower angle, or buttressing with compacted fill.
- 5.4-11:** Relatively low cohesion values were measured for remolded Saugus Formation materials, which are expected to comprise the majority of fills at the site. Additional direct shear testing shall be conducted to aid in evaluation of surficial stability of fill slopes proposed in the Preliminary Grading Plan. If surficial stability of proposed fill slopes would not be adequate based on the additional testing, one or more of the mitigation measures listed above in **Mitigation Measure 5.4-8** shall be used.
- 5.4-12:** Fill composed of mixtures of native material types typically has higher shear strength than fill composed of just one native material type. Therefore, the additional shear strength testing shall be performed on samples that represent the mixture of materials that will be placed in the proposed fills. If surficial stability of proposed fill slopes would not be adequate based on the additional testing, one or more of the mitigation measures listed above in **Mitigation Measure 5.4-8** shall be used.
- 5.4-13:** The in-situ and remolded ultimate/residual cohesion values measured by GAI for the Saugus and Pacoima Formation bedrock at the site are relatively low. Therefore, the static factor of safety of infinite 2:1 (h:v) cut and fill slopes typically is less than 1.5. One or more of the following measures shall be implemented to mitigate surficial stability of proposed cut and fill slopes, as appropriate:
- Avoidance
  - Stability fills
  - Flattening of slopes to 3:1 (h:v), or flatter
  - Seeding/planting of slopes
  - Guniting of slopes
  - Mechanically Stabilized Earth (MSE) slopes

- 5.4-14:** Settlement of areas of fill that will be deeper than 40 feet shall be monitored (by survey of settlement monuments) in order to evaluate when the settlement rate of the fill is small enough to permit issuance of building permits.
- 5.4-15:** Stability of backcuts for retaining walls, particularly the wall that will be constructed adjacent to the existing water tank, shall be evaluated from the viewpoints of wall stability and of impacts on adjacent infrastructure. The factor of safety for the backcut slope for retaining walls should be at least 1.25, including the effect of surcharge loading from construction equipment.
- 5.4-16:** Drainage features shall be designed to prevent water from ponding on graded areas and from flowing over natural or constructed slopes, and should direct surface water to designed debris basins, where applicable. Debris material generated by erosion of site materials shall be contained inside the site boundaries.
- 5.4-17:** Expansive materials at the site shall be evaluated by the Project Geotechnical Engineer during the grading plan stage of development. Expansion potential of site soils can be mitigated by controlling the water content and density of fill soils, by specifying embedment and reinforcement of structures, and by removing the expansive materials and replacing them with compacted material with low expansion potential.
- 5.4-18:** Shrinkage/bulking of on-site materials shall be estimated during future planning stages due to the presence of expansive soils on the site. The following shrinkage and bulking factors may be used for evaluation of cut and fill quantities.
- Existing artificial fill, colluvium, and alluvium are expected to reduce in volume (shrink) by as much as about 10 percent when excavated and subsequently compacted to the specified compaction density.
  - Pacoima and Saugus Formation materials are expected to increase in volume (bulk) by as much as 10 percent when excavated and subsequently compacted to the specified compaction density.
- 5.4-19:** All slopewash materials shall be removed during proposed grading operations. All alluvium beneath proposed fill areas will be removed and recompact, unless the alluvium is dense. Dense (granular) alluvium typically has a corrected Standard Penetration Test (SPT) resistance of at least 30 blows per foot or a Cone Penetration Test (CPT) resistance of at least 150 kilograms per square centimeter.

- 5.4-20:** Supplemental subsurface investigation for evaluation of the depth and lateral extent of soils with significant hydroconsolidation potential shall be performed at the Grading Plan phase of development for unexplored areas where fill will be placed. If other areas with hydroconsolidation-prone materials are discovered during grading operations, they can be mitigated by removing the hydroconsolidation prone materials and replacing them with compacted fill.
- 5.4-21:** Prior to grading, planting and irrigation of cut slopes and fill slopes shall be included in future design phases in order to improve surficial stability of slopes and to mitigate potential for erosion.
- 5.4-22:** Mitigation measures for geotechnical resources shall be implemented so as not to conflict with mitigation measures as set forth in **Section 5.3, Biological Resources**, of this EIR.

## **CUMULATIVE IMPACTS**

Geotechnical impacts are site specific in nature and each development site is subject to, at minimum, uniform site development and construction standards relative to seismic and other geologic conditions that are prevalent within the locality and/or region. Because the development of each site would have to be consistent with City of Santa Clarita requirements for projects in the City, the requirements of the Los Angeles County Department of Public Works, and the Uniform Building Code as they pertain to protection against known geologic hazards, impacts of cumulative development would be less than significant given known geologic considerations.

## **CUMULATIVE MITIGATION MEASURES**

No significant cumulative geotechnical impacts would occur; therefore, no cumulative mitigation measures are recommended.

## **UNAVOIDABLE SIGNIFICANT IMPACTS**

With implementation of the above-identified mitigation measures, project-specific impacts associated with geology and soils would be reduced to less than significant. Therefore, no unavoidable significant project-specific impacts are anticipated.