GEOTECHNICAL INVESTIGATION REPORT

May 24, 2018

State Water Resources Control Board
DFA Project Number 3600009-001P
DFA Funding Agreement Number D17-02032

Prepared For:

Apple Valley Heights County Water District
Mr. Daniel Smith
9429 Cerra Vista Street
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Apple Valley Heights County Water District – Water System Improvements
Apple Valley, CA

NV5 PROJECT NUMBER 226817-0000211.01

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May 24, 2018
NV5 Project Number 226817-0000211.01
DFA Funding Agreement Number D17-02302

Subject: Geotechnical Investigation Report

Project: Apple Valley Heights County Water District – Water System Improvements
Apple Valley, California

Dear Mr. Smith:

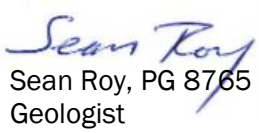
As requested, NV5 West, Inc. (NV5) is pleased to present the results of our preliminary geotechnical investigation for the subject project. The purpose of this investigation was to evaluate the subsurface conditions for the proposed water line and storage tank improvements for the Apple Valley Heights County Water District (AVHCWD). It is our understanding that the project includes the construction of two potable water tanks at the Mesa Vista Tank Site, and approximately 10,000 linear feet of water pipelines in the district's service area. The results of the geotechnical field exploration, laboratory tests, and preliminary geotechnical engineering recommendations and conclusions are presented herewith.

Based on the subsurface exploration, subsequent testing of the subsurface soils, and engineering analyses, it was concluded that the construction of the proposed project is geotechnically feasible. The geotechnical information presented herein is intended to assist the project design team and construction contractor in their understanding of the geotechnical factors affecting the proposed project, and the preliminary recommendations, should be incorporated into the project design and implemented construction.

It is recommended that the forthcoming project specifications, in particular the earthwork/compaction sections, be reviewed by NV5 Infrastructure for consistency with our report prior to the bid process in order to avoid possible conflicts, misinterpretations, and inadvertent omissions, etc. It should also be noted, that the applicability and final evaluation of the recommendations presented herein, are contingent upon construction phase field monitoring by NV5, in light of the widely acknowledged importance of geotechnical consultant continuity through the various design, planning and construction stages of a project.

NV5 appreciates the opportunity to provide this geotechnical engineering service for this project and looks forward to continuing our role as your geotechnical engineering consultant.

Respectfully submitted,
NV5 West, Inc.



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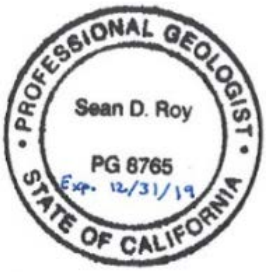

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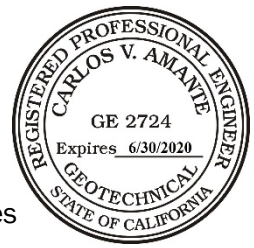

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1.0 INTRODUCTION

This report presents the results of NV5's preliminary geotechnical investigation for the proposed Apple Valley Heights County Water District (AVHCWD) water system improvements located in Apple Valley, San Bernardino County, California. The approximate location of the project area is shown in *Figure 1, Site Location Map*.

The purpose of this study was to evaluate the subsurface conditions and to provide preliminary geotechnical recommendations for the design and construction of potable water tanks and water pipelines. It is our understanding that the project includes the construction of approximately 10,000 linear feet of water pipelines within the district's service area, and of two potable water tanks at the Mesa Vista Tank Site. This report summarizes the data collected and presents our findings, conclusions, and preliminary recommendations.

This report has been prepared for the exclusive use of the client and their consultants to describe the geotechnical factors at the project site which should be considered in the design and construction of the proposed project. In particular, it should be noted that this report has not been prepared from the perspective of a construction bid preparation instrument and should be considered by prospective bidders only as a source of general information subject to interpretation and refinement by their own expertise and experience, particularly with regard to construction feasibility. Contract requirements as set forth by the project plans and specifications will supersede any general observations and specific recommendations presented in this report.

2.0 SCOPE OF SERVICES

NV5's scope of services for this project included the following tasks:

- Review of readily available background data, including in-house geotechnical data, in-house geotechnical reports, published geologic maps, topographic maps, seismic hazard maps and literature relevant to the subject site.
- Review of preliminary project plans prepared by NV5.
- A site reconnaissance to observe the general surficial site conditions and to select specific exploratory trench locations.
- Coordinating with entities having an interest in the field exploration activities including NV5, the excavation subcontractor (Kelley's Underground Construction), Underground Service Alert, agencies associated with one-call notification, and the Apple Valley Heights County Water District.
- Conducting a subsurface investigation, which included the excavation, logging, and sampling of ten (10) exploratory trenches located within the project area to depths up to approximately 10.5 feet below the existing ground surface. Soil samples obtained from the trenches were transported to NV5's in-house laboratory for observation and testing.
- Logging and sampling of the earth materials exposed in a cut slope at the Mesa Vista Tank Site.

- Performing laboratory testing on selected representative bulk and relatively undisturbed soil samples obtained during the field exploration program to evaluate their pertinent geotechnical engineering properties.
- Performing an assessment of general seismic conditions and geotechnical hazards affecting the area and potential impacts on the subject project.
- Engineering evaluation of the data collected to develop geotechnical recommendations for the design and construction of the proposed improvements.
- Preparation of this report including reference maps and graphics, presenting our findings, conclusions and geotechnical design recommendations specifically addressing the following items:
    - Evaluation of general subsurface conditions and description of types, distribution, and engineering characteristics of subsurface materials.
    - Evaluation of project feasibility including excavatability, trench stability, and suitability of on-site soils for backfill.
    - Recommendations and geotechnical parameters to be used for the design of the project, including earthwork and pipeline backfill.

3.0 PROJECT AND SITE DESCRIPTION

The project site is located in Apple Valley, in San Bernardino County, CA. The area in the vicinity of the project varies from steep slopes at the south end of the project near the Mesa Vista Tank Site on the north side of the Ord Mountains to relatively flat near the north end of the project alignment near Tussing Ranch Road. Elevations at the project site range from approximately 3,191 to 3,445 feet above mean sea level. The segment of the project along Mesa Vista Street varies from relatively rural to a suburban area developed primarily with detached single-family residences.

The proposed water lines include approximately 4,800 linear feet of new 6-inch transmission pipeline along Mesa Vista Street from Ocotillo Way to the Mesa Vista Tank Site. Parallel and adjacent to portions of the proposed transmission pipeline, approximately 1,300 linear feet of new 8-inch water distribution pipeline will be installed. The new water lines will consist of PVC C900 pipes. The project also includes construction of two 28-ft diameter, 16-ft high, steel-bolted potable water tanks to replace the three existing water tanks at the Mesa Vista Tank Site (*Figure* 2, *Alternatives P1 and P2, Dedicated Transmission Pipeline & Distribution Pipeline Improvements).* The existing pipeline will be either abandoned in place or removed.

The installation of a transmission pipeline will run from an existing well site (Well Nos. 3 and 4) north to Tussing Ranch Road for a future tie-in with Golden State Water Company. The pipeline will continue east along Tussing Ranch Road to Central Road, then north along Central Road to Houston Street, then east to Blackfoot Road. At Blackfoot Road, the pipeline will interconnect with the existing distribution system of Apple Valley Foothill County Water District (*Figure 3, Proposed AVHCWD Interconnection with AVFCWD & GSWC).*

4.0 FIELD EXPLORATION PROGRAM

Before starting NV5's field exploration program, Underground Service Alert was notified of our operations for underground utility marking at the locations of exploration prior to excavation. The subsurface conditions were explored on April 23, 2018 by excavation, logging, and sampling ten (10) exploratory trenches. The trenches were excavated to a maximum depth of 10.5 feet below the existing ground surface by Kelley's Underground Construction using a backhoe with a toothed 18-inch wide bucket.

The trenches were logged by an NV5 geologist. Representative samples of the soils encountered were obtained for visual soils classification and laboratory testing. The soil conditions encountered in the excavations were visually examined, classified, and logged in general accordance with the Unified Soil Classification System. The logs of the exploratory test trenches are presented in *Appendix A, Exploratory Test Pit Log*s. The approximate locations of the exploratory trenches (TP-1 through TP-10) are presented on *Figures 4 to 6*. Subsequent to logging and sampling the trenches were backfilled.

The bulk samples of the soils encountered in the excavations were labeled in the field and transported to our laboratory for observation and testing.

5.0 LABORATORY TESTING

Laboratory testing was performed on selected representative bulk soil samples, obtained from the exploratory excavations, to aid in the material classifications and to evaluate engineering properties of the materials encountered (see *Appendix B*). The following tests were performed:

- Moisture content (ASTM D2216);
- Particle size analyses and No. 200-wash (ASTM D422 and ASTM D1140);
- Direct shear (ASTM D3080);
- Expansion index (ASTM D4829);
- Corrosivity test series, including sulfate content, chloride content, pH-value, and electrical resistivity (CTM 417, 422, and 532/643): and
- Maximum density curve (ASTM D1557).

Testing was performed in general accordance with applicable ASTM standards and California Test Methods. A summary of the laboratory testing program and the laboratory test results are presented in *Appendix B*, Laboratory Test Results.

6.0 GEOLOGY

6.1 GEOLOGIC SETTING

The project site is located in San Bernardino County traversing the Mojave Desert and Transverse Ranges geomorphic provinces. The Mojave Desert province is a broad interior region of isolated mountain ranges separated by expanses of desert plains. It has an interior enclosed drainage and

many playas. There are two important fault trends that control topography, a prominent NW-SE trend and a secondary east-west trend (apparent alignment with Transverse Ranges is significant). The Mojave Desert province is wedged in a sharp angle between the Garlock fault (southern boundary Sierra Nevada) and the San Andreas Fault, where it bends east from its northwest trend. The northern boundary of the Mojave is separated from the prominent Basin and Range by the eastern extension of the Garlock fault. Typical stratigraphy includes pre-Mesozoic and Mesozoic (between approximately 250 and 65 million years old) igneous intrusive and metamorphic rocks, Cenozoic (less than 65 million years old) marine and non-marine sedimentary units, and Quaternary (less than approximately 2 million years old) sedimentary deposits (Powell and Matti, 1971).

The Transverse Ranges province consist of easterly trending mountains and geologic structures that are distinct from the other provinces of California that generally trend northwest-southeast. The project site is partially located within the San Bernardino Mountains of the eastern portion of the Transverse Ranges. The San Andreas Fault Zone divides the San Bernardino Mountains into two physiographic blocks with the south end of the project site being located in the northern block. This block is terminated along the northern edge by a zone of south dipping thrust faults, referred to as the North Frontal Fault Zone.

6.2 SUBSURFACE CONDITIONS

Exposed at the project site are several different geologic units. These include a bedrock unit of metamorphic rocks at the south end of the project at the Mesa Vista Tank Site (Test Pit TP-7); alluvial fan deposits downslope of the tank site (Test Pits TP-5 and TP-6); colluvial-alluvial deposits (Test Pit TP-4); Crowder Formation deposits (Test Pits TP-1, TP-2, and TP-3); and young eolian deposits at the north end of the project site (Test Pits TP-8, TP-9, and TP-10).

Geologic materials encountered during the subsurface explorations largely consisted of poorly to moderately consolidated silty sands with gravel and rock fragments. In general, the size of rock fragments increases to the south toward the San Bernardino Mountains. As encountered in the excavations, the soils ranged from yellowish brown to reddish brown, dry to moist, sandy silt to gravels. Material encountered on the southern portion of the site (TP-5 and TP-6) exhibited large cobbles and boulders up to 18 inches in diameter. Excavation TP-7 encountered bedrock two feet below the ground surface. Detailed descriptions of the earth materials encountered are presented on the boring logs in Appendix A. The regional site geology is presented on *Figure 7, Regional Geologic Map.*

6.3 GROUNDWATER

Indications of static, near-surface groundwater table were not observed or encountered during the subsurface explorations to the total depths explored. It is anticipated that groundwater will not be a constraint during construction. However, experience indicates that near-surface groundwater conditions or localized seepage zones can develop in areas where no such groundwater conditions previously existed, especially in areas where a substantial increase in surface water infiltration results

from landscape irrigation, agricultural activity, artificial recharge, storage facility leaks, or unusually heavy precipitation. Seasonal variations in the groundwater levels should be anticipated.

6.4 FAULTS

The numerous faults in southern California include active, potentially active, and inactive faults. As used in this report, the definitions of fault terms are based on those developed for the Alquist-Priolo Special Studies Zones Act of 1972 and published by the California Division of Mines and Geology (Hart and Bryant, 1997). Active faults are defined as those that have experienced surface displacement within Holocene time (approximately the last 11,000 years) and/or have been included within any of the state-designated Earthquake Fault Zones (previously known as *Alquist-Priolo Special Studies Zones*). Faults are considered potentially active if they exhibit evidence of surface displacement since the beginning of Quaternary time (approximately two million years ago) but not since the beginning of Holocene time. Inactive faults are those that have not had surface movement since the beginning of Quaternary time.

Review of the *State of California, Special Studies Zones, Apple Valley South Quadrangle, Official Map*, dated March 1, 1988 indicates that the project site lies directly adjacent to the alignment of a state-designated Earthquake Fault Zone (*Appendix C, San Bernardino County Land Use Plan, General Plan, Geologic Hazard Overlays)*. While there are no known major or active faults mapped on the project site that are interpreted to cross the proposed pipeline pathways, the mapped fault zone does trend toward the location of Test Pit TP-5 near Mesa Vista Street/Roundup Way. Evidence for active faulting at the site was not observed during the subsurface investigation. The relative location of the site to known active faults in the region is depicted on *Figure 8, Regional Fault Map*. The distance from the Mesa Vista Tank Site (Test Pit TP-7) to the projection of traces of surface rupture along major active earthquake fault zones that could affect the site are listed in the following Table 1.

Table 1 – Distance from the Site to Major Active Faults

Fault	Distance From the Site
North Frontal (West)	0.4 miles
Cleghorn	9.2 miles
Helendale – So Lockhart	10.8 miles
San Andreas	16.9 miles
San Jacinto	19.4 miles
North Frontal (East)	22.5 miles
Lenwood Lockhart – Old Woman Springs	24.9 miles
Johnson Valley (North)	29.2 miles
Landers	31.4 miles
So Emmerson – Copper Mountain	37.5 miles
Sierra Madre	37.8 miles
Clamshell - Sawpit	39.9 miles
Chino	41.7 miles
Elsinore	46.5 miles

Raymond	49.4 miles
Puente Hill	53.1 miles
Elysian Park (Upper)	57.8 miles
Verdugo	59.0 miles
San Joaquin Hills	61.8 miles
San Gabriel	63.2 miles
Hollywood	63.4 miles
Newport – Inglewood	69.0 miles
Garlock	74.9 miles

7.0 SEISMIC AND GEOTECHNICAL HAZARDS

The principal seismic considerations for most pipelines in California are damage caused by surface rupturing of fault traces, ground shaking, seismically-induced ground settlement and liquefaction. Potential impacts to the project due to faulting, seismicity and other geologic hazards are discussed in the following sections.

7.1 FAULT RUPTURE

The project site is located along the alignment of an Earthquake Fault Zone delineated by the State of California for the hazard of fault surface rupture (*Appendix C*). The surface traces of known active or potentially active faults are not known to pass directly through the site. The North Frontal (West) fault line is located approximately 0.4 mile to the north-northwest of the Mesa Vista Tank Site and trends eastward towards Mesa Vista Street. However, based on the distance to the mapped trace of the fault and the distance to the other faults in the vicinity of the site, the potential for damage due to surface rupture of faults at the project site is considered low.

7.2 SEISMIC SHAKING

The project site is located in an area of California considered a seismically active area, and as such, the seismic hazard that most likely to impact the site is ground shaking resulting from an earthquake along one of the known active faults in the region.

Seismic parameters based on the 2016 California Building Code and using the USGS Seismic Design Parameter online tool (https://earthquake.usgs.gov/designmaps/us/application.php) are provided in the table below based on site latitude = 34.4151 degrees North and longitude = 117.1821 degrees West. NV5 should be contacted to provide revisions to these parameters if other codes are specified.

The earthquake hazard level of the Maximum Considered Earthquake (MCE) is defined in ASCE 7-10 as the ground motion having a probability of exceedance of 2 percent in 50 years. The preliminary seismic design parameters for the project site are presented in the following table.

Table 2 - Recommended 2016 CBC Seismic Design Parameters

Design Parameter	Recommended Value	Reference
Site Class	C	CBC Section 1613.3.2
Seismic Use Group	IV	AWWA D103-09 Section 14.2
Mapped Spectral Accelerations for short periods, S_S	1.935g	CBC Section 1613.2.1
Mapped Spectral Accelerations for 1-sec period, S_1	0.738g	CBC Section 1613.2.1
Short-Period Site Coefficient, F_a	1.000	CBC Table 1613.3.1
Long-Period Site Coefficient, F_v	1.300	CBC Table 1613.3.1
(1) MCE_R (5% damped) spectral response acceleration for short periods adjusted for site class, S_{MS}	1.935g	CBC Section 1613.3.3
(1) MCE_R (5% damped) spectral response acceleration at 1-second period adjusted for site class, S_{M1}	0.959g	CBC Section 1613.3.3
Design spectral response acceleration (5% damped) at short periods, S_{DS}	1.290g	CBC Section 1613.3.4
Design spectral response acceleration (5% damped) at 1-second period, S_{D1}	0.639g	CBC Section 1613.3.4
Seismic Design Category	D	CBC Section 1613.3.5
(2) MCE_G Peak Ground Acceleration adjusted for site class effects, PGA_M	0.725g	ASCE 7-10 Section 11.8.3

(1) MCE_R = Risk-adjusted Maximum Considered Earthquake
(2) MCE_G = Geometric-mean Maximum Considered Earthquake

7.3 LIQUEFACTION AND SEISMICALLY-INDUCED SETTLEMENT

Liquefaction of soils can be caused by ground shaking during earthquakes. Research and historical data indicate that loose, relatively clean granular soils are susceptible to liquefaction and dynamic settlement, whereas the stability of the majority of clayey silts, silty clays and clays is not adversely affected by ground shaking. Liquefaction is generally known to occur in saturated cohesionless soils at depths shallower than approximately 50 feet. The potential for liquefaction under the same conditions of ground shaking intensity and duration will decrease for sands that are more well-graded, more irregular and gritty, coarser and denser. Also, a pronounced decrease in liquefaction potential will occur with the increase in fine-grained (i.e., silt and clay) content. Seed and others have suggested that a non-liquefiable classification be assigned if the clay fraction is 15 percent or greater (*Guidelines for Evaluating and Mitigating Seismic Hazards in California, Special Publication 117, CDMG, Ch. 6, 1997*). Dynamic settlement due to earthquake shaking can occur in both dry and saturated sands.

The potential consequences of liquefaction to engineered structures include loss of bearing capacity, buoyancy forces on underground structures (including pipelines), increased lateral earth pressures on retaining walls, and lateral spreading. Pipes constructed in soils that become liquefied may become buoyant.

The alignments of the planned water pipelines in the northern portion of the project site are underlain by loosely to moderately consolidated silty sands with gravel and rock fragments. Material encountered on the southern portion of the site (TP-5 and TP-6) exhibited large cobbles and boulders up to 18 inches in diameter. The water table is interpreted to be over 50 feet below ground surface (bgs), except within the Mojave River floodplain, where water saturated sediments occur within 50 feet bgs. No work is proposed in the Mojave River floodplain. Therefore, the potential for liquefaction and seismically induced settlement is considered low.

7.4 LANDSLIDES AND SLOPE INSTABILITY

There are steep slopes on or in close proximity to the project site at the Mesa Vista Tank Site location. However, based on the investigation and our review of published maps and aerial photography, there appears to be no indications of landslides or deep-seated instability at the site. The surface soils along the slopes near the tank site were observed to be loose, soft, and potentially subject to creep or shallow slumping. It is NV5's opinion that the potential damage to the planned pipelines and water tanks due to landsliding or slope instability is considered low.

7.5 ROCKFALLS

During the site reconnaissance, several outcrops of loose, large boulders were observed immediately above the Mesa Vista Tank Site that could create a rockfall potential during seismic shaking. It is NV5's opinion that the potential damage due to rockfalls is considered moderate.

7.6 SUBSIDENCE

Typically, soil subsidence occurs when groundwater (near the surface or in a deep aquifer) is lowered past its historical level. This occurrence results in an increase of effective stress within a soil layer which typically translates into additional soil consolidation. The site is not located in an area of known ground subsidence due to the withdrawal of subsurface fluids. Accordingly, the potential for subsidence occurring at the site due to the withdrawal of oil, gas, or water is considered low.

7.7 TSUNAMIS, INUNDATION SEICHES, AND FLOODING

The project site varies in elevation from 3,191 to 3,445 feet above mean sea level and is approximately 70 miles from the Pacific Ocean. Therefore, tsunamis (seismic sea waves) are not considered a hazard at the site.

The site is not located near to or downslope of, any large body of water that could affect the site in the event of an earthquake-induced failure or seiche (oscillation in a body of water due to earthquake shaking).

7.8 EXPANSIVE SOILS

The project site is underlain predominantly by granular alluvial soils with gravel and rock fragments. These materials are generally considered to have very low to low expansion potential. These materials are generally considered suitable for use as structural fills, backfill of pipeline trenches, temporary excavations, or other underground structures.

8.0 CONCLUSIONS AND DESIGN RECOMMENDATIONS

8.1 GENERAL

Based on the data obtained from the subsurface exploration, the associated laboratory test results, engineering analyses, and experience with similar site conditions, it is NV5's opinion that the proposed pipeline and tank construction project is feasible from a geotechnical standpoint, provided that the recommendations in this report are incorporated into the design plans and implemented during construction. The following sections present detailed recommendations and parameters pertaining to the geotechnical engineering design for this project.

8.2 EARTHWORK

Grading plans for the Mesa Vista Tank Site have not been prepared for the project as of the date of this Report and should be reviewed by the Geotechnical Consultant. However, any project earthwork should be performed in accordance with the following recommendations and the Typical Earthwork Guidelines provided in *Appendix D*. In the event of conflict, the recommendations presented herein supersede those of *Appendix D*.

- Clearing and Grubbing - Prior to grading, the project area should be cleared of all significant surface vegetation, demolition rubble, trash, pavement, debris, etc. Any buried organic debris or other unsuitable contaminated material encountered during subsequent excavation and grading work should also be removed. Removed material and debris should be properly disposed of offsite. Holes resulting from removal of buried obstruction which extend below finished site grades should be filled with properly compacted soils. Any utilities within tank footprints should be appropriately abandoned.

- Site Grading –The proposed water tanks should be founded entirely on a cut pad in native bedrock. A cut-fill transition condition should not be allowed underlying the tanks. In order to create a uniform bearing condition for the proposed water tanks, including any adjacent perimeter

hardscape features (i.e., walls, walkways, etc.), all areas to receive surface improvements or fill soils should be treated as follows:

- Tank Pad: To create a uniform pad, the cut pad should be scarified 8 to 10 inches, moisture conditioned to within 2 percent of the optimum moisture content, and recompacted to a minimum of 95% relative compaction (based on ASTM D1557).
- Paved Areas, Flatwork: Excavate to a depth of at least 12 inches below the proposed or existing subgrade elevation, whichever is greater and replace with non-expansive compacted fill (Expansion index not exceeding 20). These excavations should extend a horizontal distance of at least 2 feet beyond the outside perimeter.
- Excavatability – Based on our subsurface exploration, it is anticipated that the majority of on-site surface soils can be excavated by modern conventional heavy-duty excavating equipment in good operating conditions. Deep excavation of resistant bedrock at the Mesa Vista Tank Site may require jack hammering or excavation techniques such as blasting. Jack hammering maybe needed at the Mesa Vista Tank Site for foundation excavations deeper than 2.5 feet below ground surface due to hard rocks.
- Structural Fill Placement - Areas to receive fill and/or surface improvements should be scarified to a minimum depth of 6 inches, brought to near-optimum moisture conditions, and compacted to at least 95 percent relative compaction, based on laboratory standard ASTM D1557. Fill soils should be brought to near-optimum moisture conditions and compacted in uniform lifts to at least 95 percent relative compaction (ASTM D1557). Rocks with a maximum dimension greater than 4 inches should not be placed in the upper 3 feet of pad grade. The optimum lift thickness to produce a uniformly compacted fill will depend on the size and type of construction equipment used. In general, fill should be placed in uniform lifts not exceeding 8 inches in loose thickness. Placement and compaction of fill should be observed and tested by the geotechnical consultant.
- Graded Slopes – Graded slopes should be constructed at a gradient of 2:1 (H:V) or flatter. To reduce the potential for surface runoff over slope faces, cut slopes should be provided with brow ditches and berms should be constructed at the top of fill slopes. Minor slopes (less than 10 feet in height) may be allowed and should be considered on a case-by-case basis.
- Import Soils - Import soils should be sampled and tested for suitability by NV5 prior to delivery to the site. Imported fill materials should consist of clean granular soils free from vegetation, debris, or rocks larger than 3 inches in maximum dimension. The Expansion Index (EI) value should not exceed a maximum of 20 (i.e., essentially non-expansive).

8.3 UTILITY TRENCHING AND TEMPORARY EXCAVATIONS

Excavation of the on-site surficial soils may be achieved with conventional heavy-duty grading equipment. Temporary, unsurcharged, excavation walls may be sloped back at an inclination of 1:1 (H:V) within fill and natural materials. Utility trench excavations should be shored in accordance with guidelines and regulations set forth by Cal-OSHA. For planning purposes, the alluvial soils may be considered a Type C soil, as defined by the current Cal-OSHA soil classification. Stockpiled (excavated) materials should be placed no closer to the edge of a trench excavation than a distance defined by a line drawn upward from the bottom of the trench at an inclination of 1:1 (H:V), but no closer than 4 feet. All trench excavations should be made in accordance with Cal-OSHA requirements.

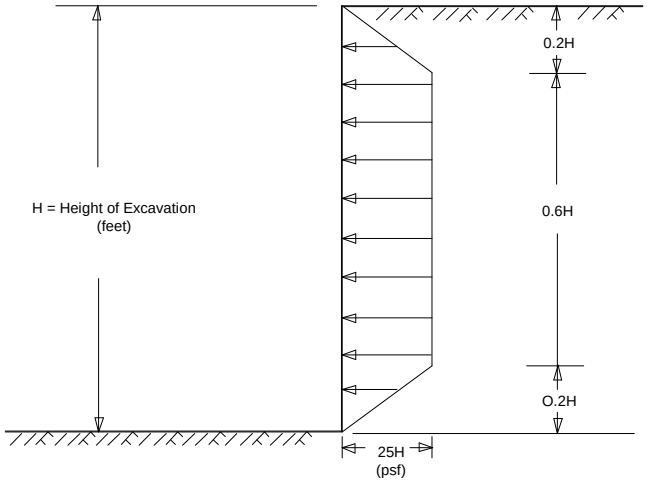
Temporary, shallow excavations with vertical side slopes less than 4 feet high will generally be stable, although due to the granular characteristics of the soil materials, there is a potential for localized sloughing. In these soil types, vertical excavations greater than 4 feet high should not be attempted without proper shoring to prevent local instabilities. For vertical excavations less than about 15 feet in height, cantilevered shoring may be used. Cantilevered shoring may also be used for deeper excavations; however, the total deflection at the top of the wall should not exceed one inch. Therefore, shoring of excavations deeper than about 15 feet may need to be accomplished with the aid of tied back earth anchors.

The actual shoring design should be provided by a registered civil engineer in the State of California experienced in the design and construction of shoring under similar conditions. Once the final excavation and shoring plans are complete, the plans and the design should be reviewed by NV5 for conformance with the design intent and geotechnical recommendations. The shoring system should further satisfy requirements of Cal-OSHA. In some areas, Shoring may be accomplished with hydraulic shores and trench plates, soldier piles and lagging and/or trench boxes. The actual method of a shoring system should be provided and designed by a contractor experienced in installing temporary shoring under similar soil conditions. If soldier piles and lagging are to be used, we should be contacted for additional recommendations.

Personnel from NV5 should observe the excavation so that any necessary modifications based on variations in the encountered soil conditions can be made. All applicable safety requirements and regulations, including Cal-OSHA requirements, should be met.

Where sloped excavations are used, the tops of the slopes should be barricaded so that vehicles and storage loads are not located within 10 feet of the tops of excavated slopes. A greater setback may be necessary when considering heavy vehicles, such as concrete trucks and cranes. NV5 should be advised of such heavy loadings so that specific setback requirements may be established. If the temporary construction slopes are to be maintained during the rainy season, berms are recommended along the tops of the slopes, to prevent runoff water from entering the excavation and eroding the slope faces.

For design of cantilevered shoring, a triangular distribution of lateral earth pressure may be used. It may be assumed that the drained soils, with a level surface behind the cantilevered shoring, will exert an equivalent fluid pressure of 32 pcf. Tied-back or braced shoring should be designed to resist a trapezoidal distribution of lateral earth pressure. The recommended pressure distribution, for the case where the grade is level behind the shoring, is illustrated in the following diagram with the maximum pressure equal to 25H in psf, where H is the height of the shored wall in feet.



Any surcharge (live, including traffic, or dead load) located within a 1:1 (H:V) plane drawn upward from the base of the shored excavation should be added to the lateral earth pressures. The lateral load contribution of a uniform surcharge load located across the 1:1 (H:V) zone behind the excavation walls may be calculated by using *Figure 9, Lateral Surcharge Loads*. Lateral load contributions of surcharges can be provided once the load configurations and layouts are known. As a minimum, a 2-ft equivalent soil surcharge is recommended to account for nominal construction loads.

8.4 DEWATERING

Groundwater was not encountered to the maximum depth explored of 10.5 feet below the existing ground surface. Dewatering is not generally anticipated during the proposed construction. However, any cases of localized seepage or heavy precipitation should be monitored during construction. The groundwater table is subject to fluctuations in response to a number of factors. If necessary, dewatering may be achieved by means of excavating a series of shallow trenches directed by gradient (i.e., gravity) to sumps with pumps. In any case, the actual means and methods of any dewatering scheme should be established by a contractor with local experience. It is important to note that temporary dewatering, if necessary, will require a permit and plan that complies with RWQCB regulations. If excessive water is encountered, NV5 should be contacted to provide additional recommendations for temporary construction dewatering. Any cases of localized seepage or heavy precipitation should be monitored during construction. Based on the subsurface exploration the onsite soils maybe considered to be relatively permeable.

8.5 TRENCH BOTTOM STABILITY

The bottom of onsite excavations will likely expose loose to medium dense silty sands, well graded sands, and some gravels north of Roundup Way. South of Roundup Way, the bottom of onsite excavations will likely expose loose to medium dense silty, sandy, gravels with subangular cobbles and boulders with size up to 18 inches or possibly larger, which should provide a suitable base for

construction of the pipelines. For the design of flexible conduits, a modulus of soil reaction (E'), of 2000 pounds per square inch (psi) is recommended.

Groundwater was not encountered during the geotechnical investigation. However, if the soils become wet or saturated they may be prone to settlement due to construction activities such as placement and compaction of backfill soils. Buried improvements underlain by these soils could also be damaged or subjected to unacceptable settlement due to subsidence of these soils. If wet or unusually soft conditions are encountered in the trench bottom, the bottom of the excavations will need to be stabilized. A typical stabilization method includes overexcavation of the soft or saturated soil and replacement with properly compacted fill, gravel or lean concrete to form a "mat" or stable working surface in the bottom of the excavation. There are other acceptable methods that can be implemented to mitigate the presence of compressible soils or unstable trench bottom conditions, and specific recommendations for a particular alternative can be discussed based on the actual construction techniques and conditions encountered.

8.6 PIPE BEDDING

It is recommended that pipe bedding materials be placed in the trench to provide uniform support and protection for the pipe. Bedding is defined as that material supporting, surrounding and extending to one foot above the top of the pipe. A cement slurry may not be used as bedding. The bedding materials should be approved by the geotechnical consultant prior to hauling on site. A minimum 6-inch layer of pipe bedding should be placed beneath the pipe consisting of sand or other granular material and shall have a minimum sand equivalent (SE) of 30. This zone shall be compacted to a minimum of 90% relative compaction. Care should be taken by the contractor during placement of the pipe bedding so that uniform contact between the bedding and pipe is attained. Pipe bedding should be placed in loose lift thicknesses not exceeding 8 inches and compacted by mechanical means to attain a relative compaction of 90 percent based on ASTM D1557. Mechanical compaction and hand tamping should be performed carefully as to not damage the pipe. This pipe backfill material should be compacted in accordance with the recommendations in the following section.

8.7 BACKFILL PLACEMENT AND COMPACTION

The majority of the on-site soils should generally be suitable for use as backfill material. Screening may be required in some areas where rocks larger than 3 inches in diameter are present. Backfill should be placed in loose lifts not exceeding 8 inches in thickness and compacted to at least 90 percent of the maximum dry density as evaluated by the latest version of ASTM D1557. Trench backfill should be compacted in uniform lifts (not exceeding 6 inches in compacted thickness) by mechanical means to at least 90 percent relative compaction (ASTM D1557).

Water jetting should not be used for compaction. The pipe bedding and cover (minimum 6-inch bedding and 12-inch cover) should consist of free-draining sand or small gravel with a minimum sand equivalent of 30 (e.g., ASTM C-33 concrete sand). There should be sufficient clearance along the side of the utility pipe or line to allow for compaction equipment. The pipe bedding shall be compacted

under the haunches and alongside the pipe. Imported backfill should consist of granular, non-expansive soil with an Expansion Index (EI) of 20 or less and should not contain any contaminated soil, expansive soil, debris, organic matter, or other deleterious materials. The sand equivalent (SE) of the imported material shall be 20 or greater. Import material should be evaluated for suitability by the geotechnical consultant prior to transport to the site.

The upper 12 inches of subgrade soil and all rock base should be compacted to at least 95 percent. The moisture content of the backfill should be maintained within 2 percent of optimum moisture content during compaction. All backfill should be mechanically compacted. Flooding or jetting is not recommended and should not be allowed.

8.8 JACK-AND-BORE CONSTRUCTION CONSIDERATIONS

It is understood that pipeline construction may use jack-and-bore construction methods for pipeline crossing beneath Roundup Way.

Groundwater was not encountered at the anticipated depths of the planned jack and bore construction. It is, therefore, anticipated that dewatering will not be needed at the locations of the access pits for the jack-and-bore construction. If seepage is encountered, for the most part, dewatering can likely be accomplished by the use of sump pumps placed a minimum of 3 feet below the lowest elevation of the bottom of these excavations. Discharge of pumped groundwater should be in accordance with regulatory requirements of the National Pollution Discharge Elimination System (NPDES), California Regional Water Quality Control Board (CRWQCB) and any other regulatory requirements.

NV5 recommends an allowable lateral earth pressure of 1,500 pounds per square foot be used for the design jacking pressure for the lateral boring equipment. The allowable pressure assumes dewatered conditions. Jack-and-bore construction should be in accordance with applicable provisions of Cal-OSHA and applicable provisions of the State of California labor codes.

8.9 WATER TANK FOUNDATIONS

Ringwall foundations should be designed using the geotechnical design parameters presented in Table 3. Footings should be designed and reinforced in accordance with the recommendations of the structural engineer and should conform to the 2016 California Building Code and the current American Water Works Association standards.

Table 3
Geotechnical Design Parameters
Foundation for Proposed Water Tanks

Ringwall Footing Dimensions	Ringwall footing at least 24 inches in width and at least 24 inches below the lowest adjacent grade.
Allowable Bearing Capacity (dead-plus-live load)	5,000 pounds per square foot (psf) A one-third (1/3) increase is allowed for transient live loads from wind or seismic forces.
Reinforcement	Reinforce in accordance with requirements as provided by the project Structural Engineer.
Estimated Settlements (Total/Differential)	Less than 1-inch/ less than ½-inch
Coefficient of Friction	0.45
Lateral Passive Resistance (Equivalent Fluid Pressure)	300 pounds per cubic foot (pcf) One third (1/3) increase in passive value may be used for wind and seismic loads. The total lateral resistance may be taken as the sum of the frictional resistance and the passive resistance, provided that the passive bearing resistance does not exceed one-half (1/2) of the total resistance.

8.10 SLOPE STABILITY

Grading plans for the Mesa Vista Tank Site have not been prepared for the project as of the date of this Report and should be reviewed by the Geotechnical Consultant. Based on the loose nature of the soils on the hillsides, shallow slumping and/or debris wash should be considered a potential nuisance. Due to the potential for damage from rockfalls, the construction of a properly designed buffer zone and/or concrete deflection walls (or equivalent fencing) should be considered. Additional mitigation measures would be to stabilize the rocks in place or by removing loose boulders.

8.11 FOUNDATIONS FOR ANCILLARY STRUCTURES

A shallow foundation system may be used for support of relatively lightly loaded ancillary structures, such as site screen walls, equipment buildings, light standards, etc. The foundations for each feature should be supported entirely on natural soil or on compacted fill prepared in accordance with the recommendations in Section 8.2 of this report. Shallow foundations should be designed using the geotechnical design parameters presented in Table 4. Footings should be designed and reinforced in

accordance with the recommendations of the structural engineer and should conform to the 2016 California Building Code and the current American Water Works Association (AWWA) standards.

Table 4
Geotechnical Design Parameters
Foundation for Ancillary Structures

Footing Dimensions	Footing at least 12 inches in width and at least 12 inches below the lowest adjacent grade.
Allowable Bearing Capacity (dead-plus-live load)	2,500 pounds per square foot (psf) A one-third (1/3) increase is allowed for transient live loads from wind or seismic forces.
Reinforcement	Reinforce in accordance with requirements as provided by the project Structural Engineer.
Estimated Settlements (Total/Differential)	Less than 1-inch/ less than ½-inch
Coefficient of Friction	0.45
Lateral Passive Resistance (Equivalent Fluid Pressure)	300 pounds per cubic foot (pcf) One-third (1/3) increase in passive value may be used for wind and seismic loads. The total lateral resistance may be taken as the sum of the frictional resistance and the passive resistance, provided that the passive bearing resistance does not exceed one-half (1/2) of the total lateral resistance.

8.12 CORROSION POTENTIAL

The corrosion characteristics of on-site soils should be considered in the design of any buried or grade supported structures in contact with the soils in accordance with *Caltrans Corrosion Guidelines.*

Caltrans' *Corrosion Guidelines* (version 2.1, 2015) define corrosive soils as, "*Chloride concentration is 500 ppm or greater, sulfate concentration is 2000 ppm or greater, or the pH is 5.5 or less*". Minimum resistivity in soil or water is considered an indicator parameter and is not used to define a corrosive soil environment. Caltrans' *Guidelines* state that a "*minimum resistivity value for soil and/or water less than 1000 Ohm-cm indicates the presence of high quantities of soluble salts and a higher propensity for corrosion*".

Representative samples of the site soils obtained from our exploratory test pits were tested to evaluate the corrosion potential. The tests include pH, electrical resistivity, and soluble chloride and sulfate concentrations. Results of the corrosivity tests performed are summarized in the table below and presented in *Appendix B – Laboratory Testing*.

Table 5 - Corrosivity Test Results

Test Location	Test Pit TP-5	Test Pit TP-7	Test Pit TP-10
Depth (feet)	6-8'	1-2'	3-5'
pH	8.4	8.8	8.0
Electrical Resistivity (Ohm-cm)	8100	4400	4100
Chloride Content (ppm)	11	11	11
Soluble Sulfate Content (ppm)	63	33	51

Based on experience and the *Caltrans Corrosion Guidelines* dated January 2015, the on-site soils have low corrosion potential to concrete and steel substructures.

Any imported soils should be evaluated for corrosion characteristics if they will be in contact with buried or at-grade structures and appropriate mitigation measures should be included in the structure design. It is recommended that a corrosion specialist be contacted to determine if mitigation measures are necessary.

9.0 DESIGN REVIEW AND CONSTRUCTION MONITORING

Geotechnical review of plans and specifications is of paramount importance in engineering practice. The poor performance of many pipelines has been attributed to inadequate geotechnical review of construction documents. Additionally, observation and testing of the backfill, subgrade and base will be important to the performance of the proposed improvements. The following sections present our recommendations relative to the review of construction documents and the monitoring of construction activities.

9.1 PLANS AND SPECIFICATIONS

The design plans and specifications should be reviewed and approved by NV5 prior to bidding and construction, as the geotechnical recommendations may need to be re-evaluated in the light of the actual design configuration. This review is necessary to evaluate whether the recommendations contained in this report and future reports have been properly incorporated into the project plans and specifications.

9.2 CONSTRUCTION MONITORING

Site preparation, removal of unsuitable soils, assessment of imported fill materials, backfill placement, and other earthwork operations should be observed and tested. The substrata exposed during the construction may differ from that encountered in the test excavations. Continuous observation by a representative of NV5 during construction allows for evaluation of the soil/rock conditions as they are encountered, and allows the opportunity to recommend appropriate revisions where necessary.

10.0 LIMITATIONS

The recommendations and opinions expressed in this report are based on NV5's review of background documents and on information developed during this study. It should be noted that this study did not evaluate the possible presence of hazardous materials on any portion of the site. More detailed limitations of this geotechnical study are presented in the ASFE's information bulletin in *Appendix E*.

Due to the limited nature of our field explorations, conditions not observed and described in this report may be present on the site. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation and laboratory testing can be performed upon request. It should be understood that conditions different from those anticipated in this report may be encountered during the proposed structure construction operations.

Site conditions, including ground-water level, can change with time as a result of natural processes or the activities of man at the subject site or at nearby sites. Changes to the applicable laws, regulations, codes, and standards of practice may occur as a result of government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which NV5 has no control.

NV5's recommendations for this site are, to a high degree, dependent upon appropriate quality control of subgrade preparation, fill/backfill placement, etc. Accordingly, the recommendations are made contingent upon the opportunity for NV5 to observe grading operations and foundation excavations for the proposed construction. If parties other than NV5 are engaged to provide such services, such parties must be notified that they will be required to assume complete responsibility as the geotechnical engineer of record for the geotechnical phase of the project by concurring with the recommendations in this report and/or by providing alternative recommendations.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. NV5 should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

NV5 has endeavored to perform this study using the degree of care and skill ordinarily exercised under similar circumstances by reputable geotechnical professionals with experience in this area in similar

soil/rock conditions. No other warranty, either expressed or implied, is made as to the conclusions and recommendations contained in this study.

11.0 SELECTED REFERENCES

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FIGURES

Reference: Google Earth 2018

No Scale

N

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Project No: **226817-0000211**
Drawn: **SR**
Date: **April 2018**

Site Location Map
Apple Valley CWD
Water System Improvements
Apple Valley, California **Figure No. 1**

DATE: 5/16/18 TIME: 1:36:58 PM PATH: N:\226817-0000211-00\CADD\FIGURES\ LAYOUT: 8.5x11_PDF
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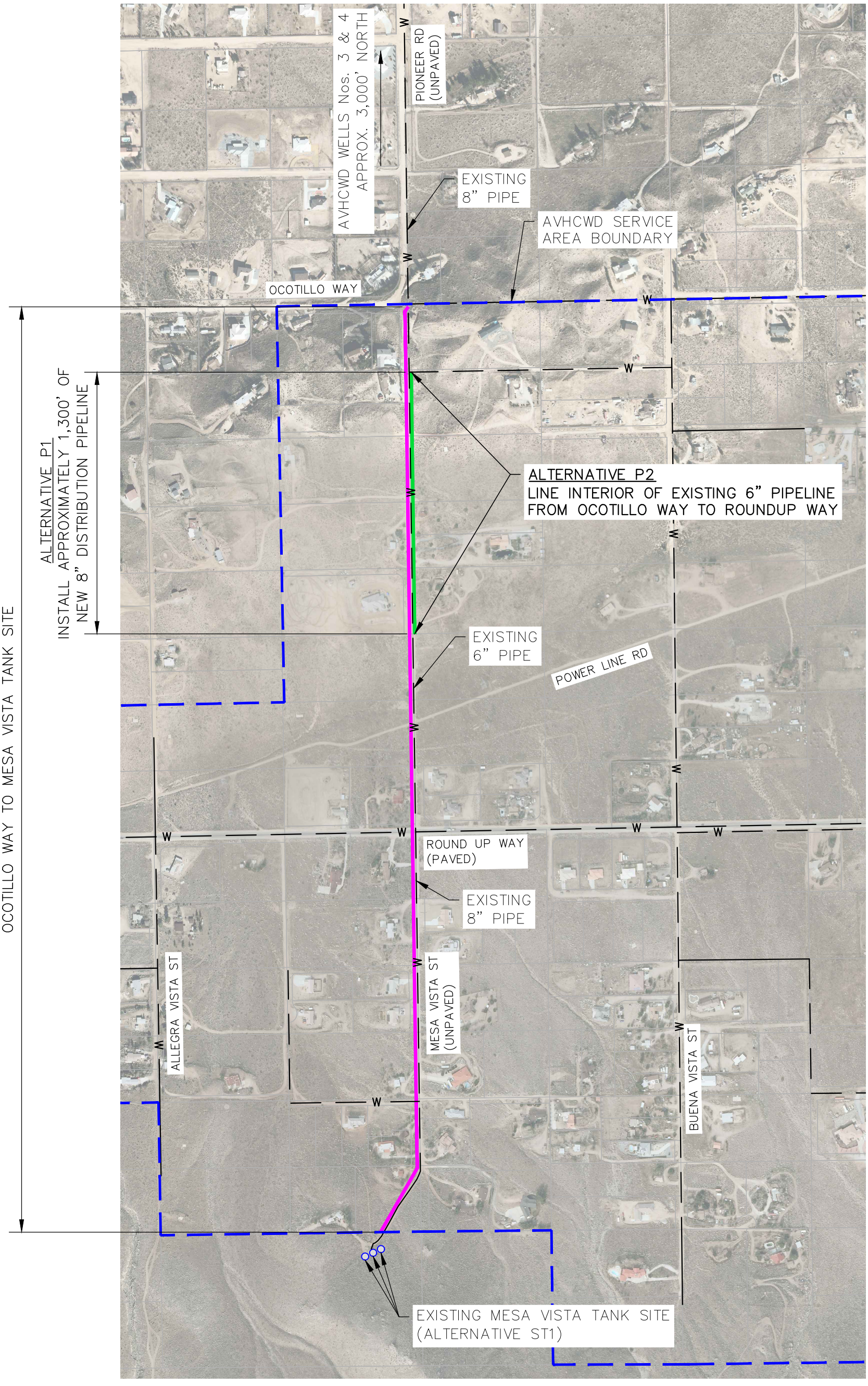

ALTERNATIVE P1
INSTALL APPROXIMATELY 4,800' OF NEW 6" TRANSMISSION PIPELINE
OCOTILLO WAY TO MESA VISTA TANK SITE

LEGEND

- SERVICE AREA BOUNDARY OF APPLE VALLEY HEIGHTS COUNTY WATER DISTRICT (CA3600009)
- W — EXISTING PIPELINE
- PROPOSED TRANSMISSION PIPELINE
- PROPOSED DISTRIBUTION PIPELINE

0 500' 1,000'
SCALE: 1"= 500'

PRELIMINARY
NOT FOR CONSTRUCTION

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PRELIMINARY ENGINEERING REPORT

ALTERNATIVES P1 & P2

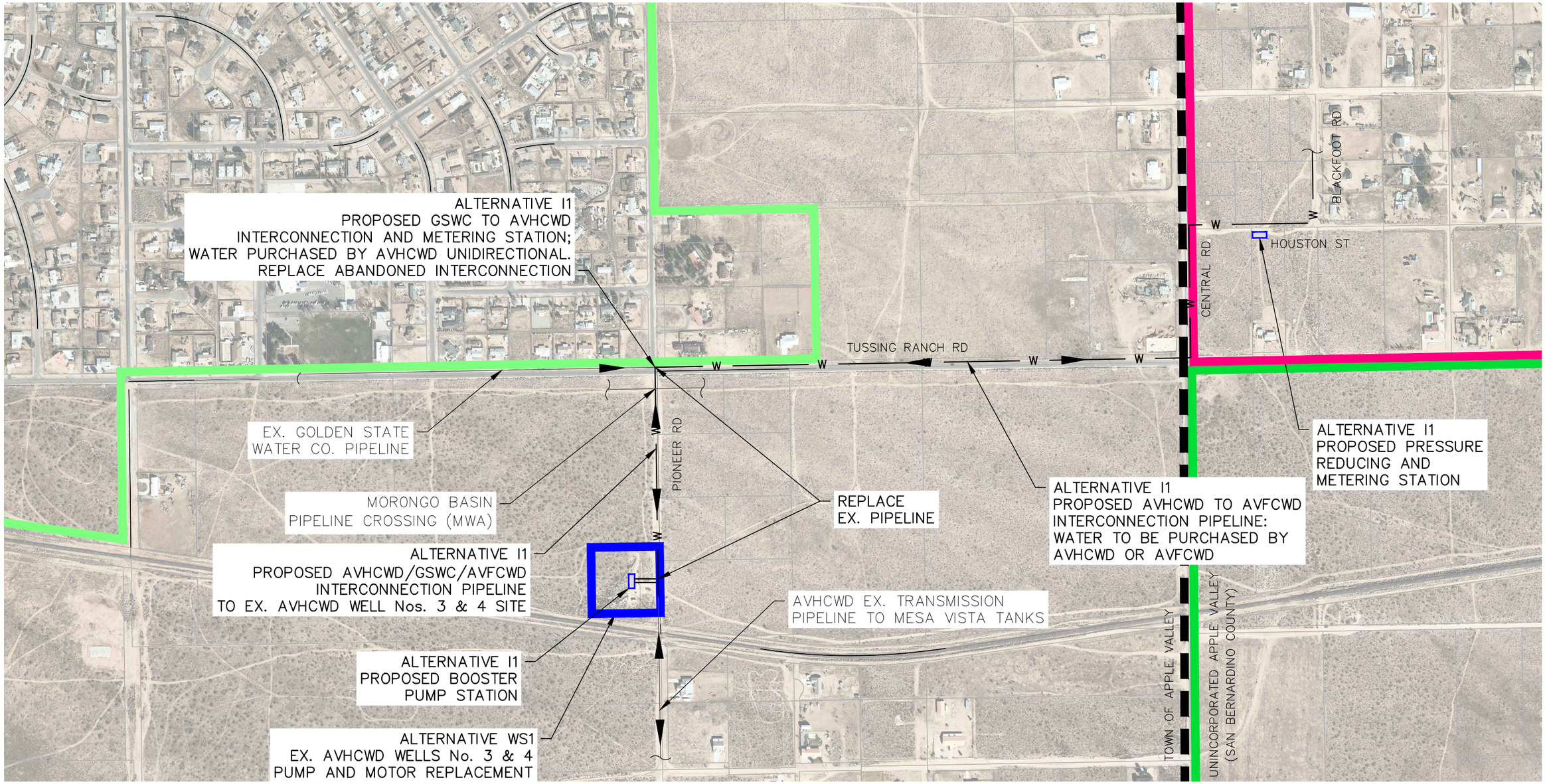
DEDICATED TRANSMISSION PIPELINE & DISTRIBUTION PIPELINE IMPROVEMENTS

FIGURE 2

PREPARED FOR: APPLE VALLEY HEIGHTS COUNTY WATER DISTRICT

DATE SUBMITTED: MAY 2018

JOB NUMBER 226817-0000211



LEGEND

- APPLE VALLEY HEIGHTS COUNTY WATER DISTRICT (CA3600009)
- MARIANA RANCHOS COUNTY WATER DISTRICT (CA3610030)
- APPLE VALLEY FOOTHILL COUNTY WATER DISTRICT (CA3600008)
- GOLDEN STATE WATER COMPANY – APPLE VALLEY SOUTH SYSTEM
- TOWN OF APPLE VALLEY CITY LIMITS

0 500' 1,000'

SCALE: 1"= 500'

PRELIMINARY
NOT FOR CONSTRUCTION

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PRELIMINARY ENGINEERING REPORT

PROPOSED AVHCWD INTERCONNECTION WITH AVFCWD & GSWC

FIGURE 3

PREPARED FOR: APPLE VALLEY HEIGHTS CWD

DATE SUBMITTED: MAY 2018

JOB NUMBER **226817-0000211**

MAP SYMBOLS

Test Pit — Approximate location of geotechnical test pit excavation

Approximate scale in feet

0 200 400 600 800 1,000

Reference: Google Earth 2018

N

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Site Vicinity Map 1 of 3

Apple Valley CWD
Water System Improvements
Apple Valley, California

Figure No. 4

MAP SYMBOLS

Approximate location of geotechnical boring

Test Pit

Approximate scale in feet

0 100 200 300 400 500

Reference: Google Earth 2018

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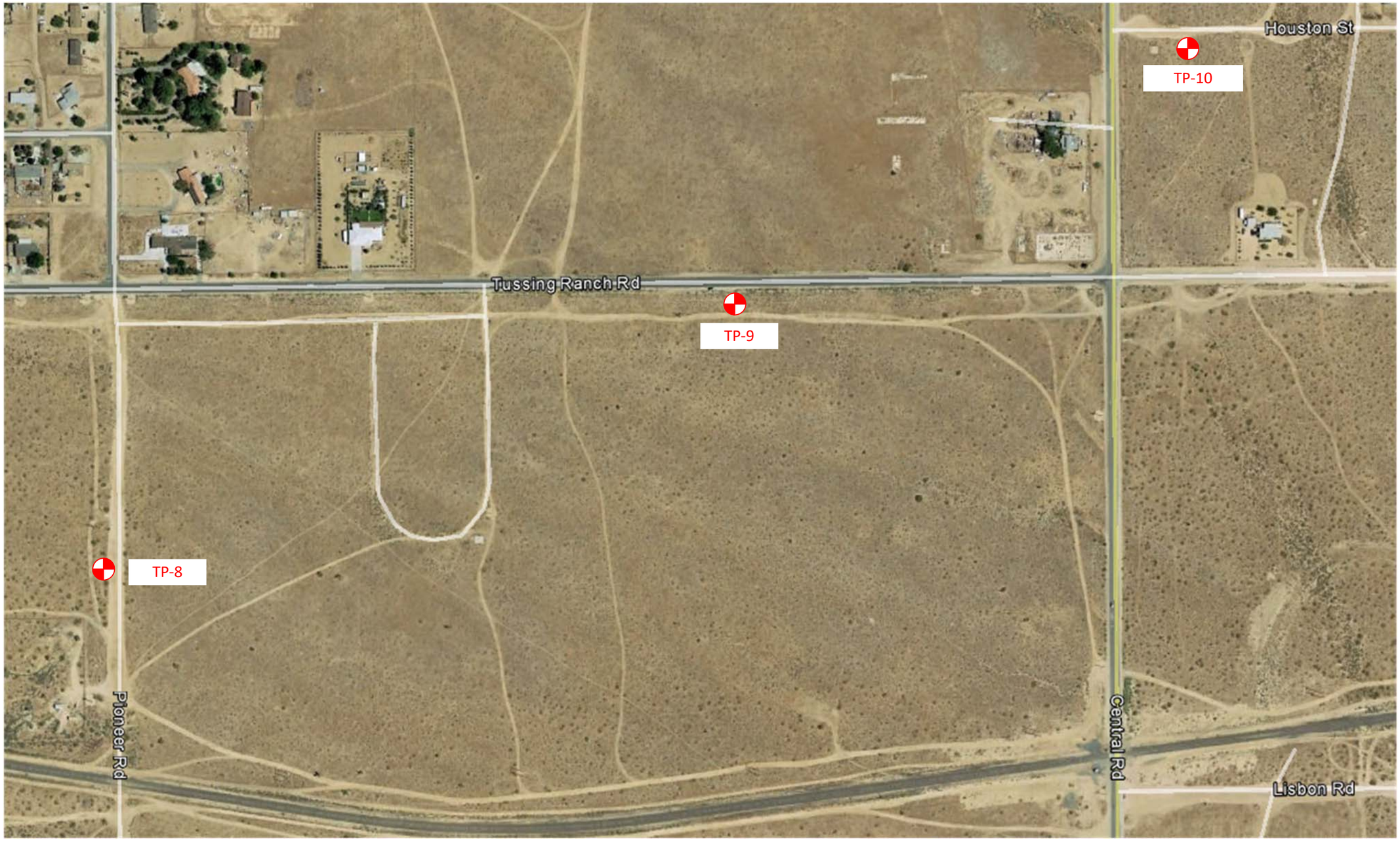
Site Vicinity Map 2 of 3

Apple Valley CWD
Water System Improvements
Apple Valley, California

Figure No. 5



MAP SYMBOLS

Test Pit — Approximate location of geotechnical boring

Approximate scale in feet

0 200 400 600 800 1000

N

Reference: Google Earth 2018

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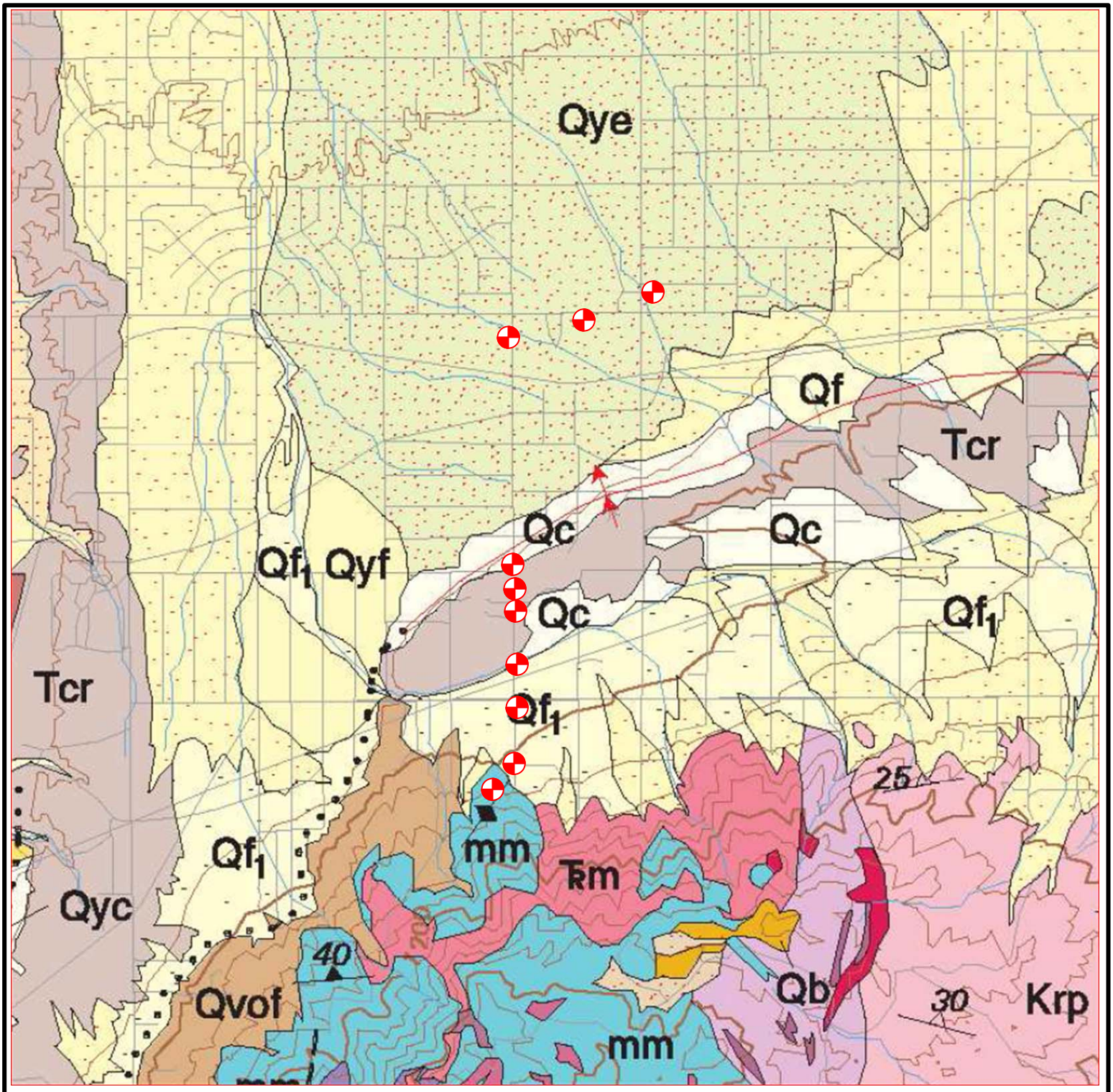
Site Vicinity Map 3 of 3
Apple Valley Heights CWD
Water System Improvements
Apple Valley, California **Figure No. 6**



DESCRIPTION OF MAP UNITS

Qye – Young eolian deposits
Qf – Very young alluvial fan deposits
Qf1 – Very young alluvial fan deposits, Unit 1
Qc – Very young colluvial deposits
Qyf – Young alluvial fan deposits
Qyc – Young colluvial deposits
Qb – Sedimentary breccia
Qvof – Very old fan deposits
Krp – Porphyritic monzogranite
Tcr – Crowder Formation
TRm – Monzogranite of Manzanita Springs
mm – Metamorphic rocks, marble dominant

MAP SYMBOLS

Approximate location of geotechnical test pit

Approximate Scale in Miles

0 0.25 0.5 0.75 1.0 1.25

N

Reference: Morton, D.M., and Miller, F.K.: *Geologic Map of the San Bernardino and Santa Ana 30' x 60' Quadrangles, California [Sheet 1 of 4],* U.S. Geological Survey OF-2006, Dated 2006.

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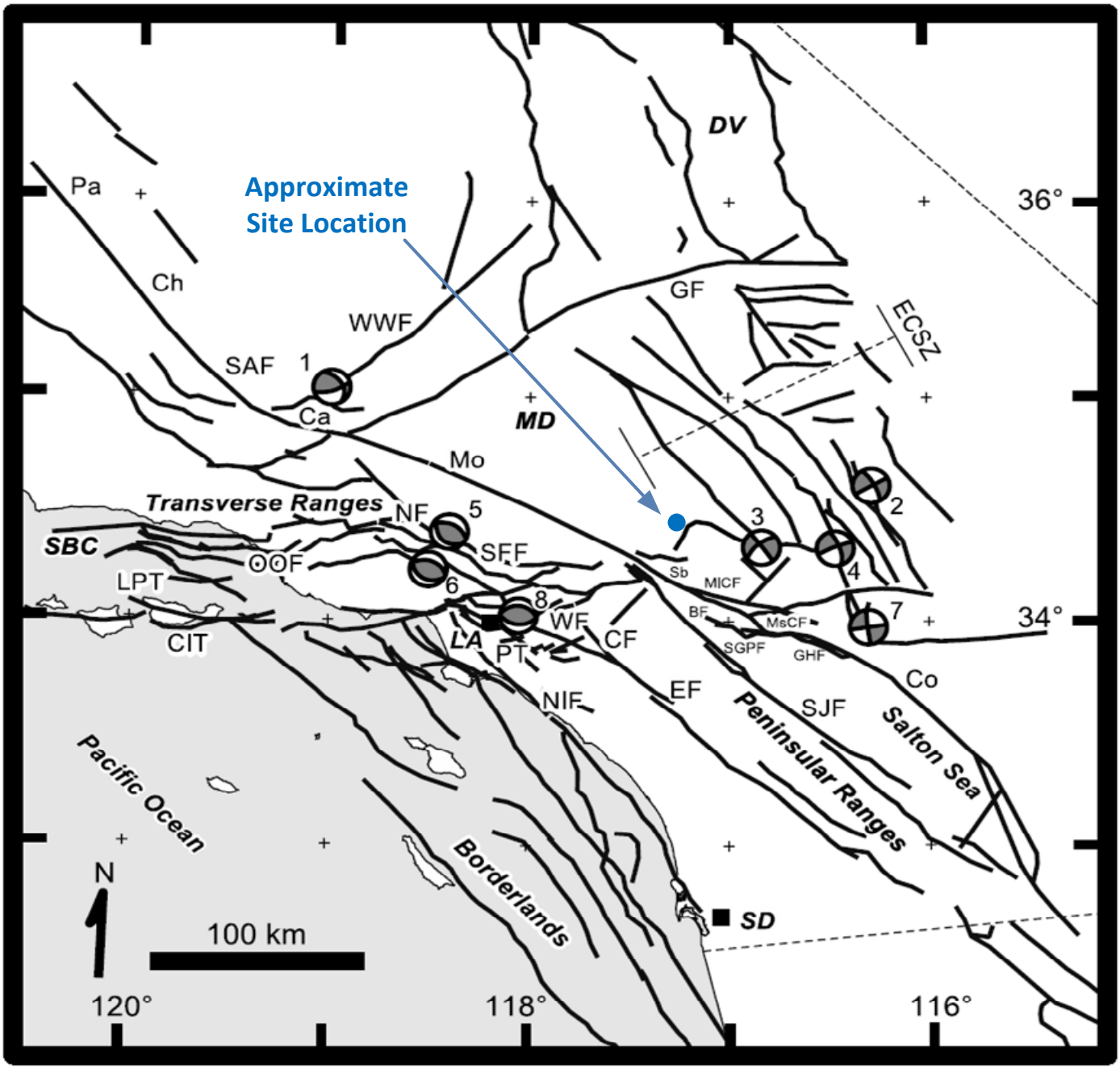
General Geologic Map
Apple Valley Heights CWD Water System Improvements
Apple Valley, California

Figure No. 7



Map of southern California showing the geographic regions, faults and focal mechanisms of the more significant earthquakes. **Regions:** Death Valley, DV; Mojave Desert MD; Los Angeles, LA; Santa Barbara Channel, SBC; and San Diego, SD. **Indicated Faults:** Banning fault, BF; Channel Island thrust, CIT; Chino fault, CF; Eastern California Shear Zone, ECSZ; Elsinore fault, EF; Garlock fault, GF; Garnet Hill fault, GHF; Lower Pitas Point thrust, LPT; Mill Creek fault, MICF; Mission Creek fault, MsCF; Northridge fault, NF; Newport Inglewood fault, NIF; offshore Oak Ridge fault, OOF; Puente Hills thrust, PT; San Andreas fault (sections: Parkfield, Pa; Cholame, Ch; Carrizo; Ca; Mojave, Mo; San Bernardino, Sb; and Coachella, Co); San Fernando fault, SFF; San Gorgonio Pass fault, SGPF; San Jacinto fault, SJF; Whittier fault, WF; and White Wolf fault, WWF. **Earthquake Focal Mechanisms:** 1952 Kern County, 1; 1999 Hector Mine, 2; 1992 Big Bear, 3; 1992 Landers, 4; 1971 San Fernando, 5; 1994 Northridge, 6; 1992 Joshua Tree, 7; and 1987 Whittier Narrows, 8.

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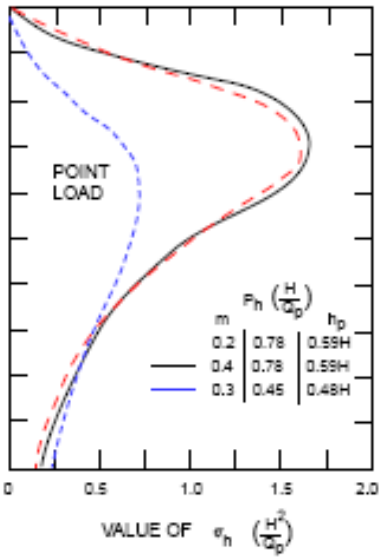
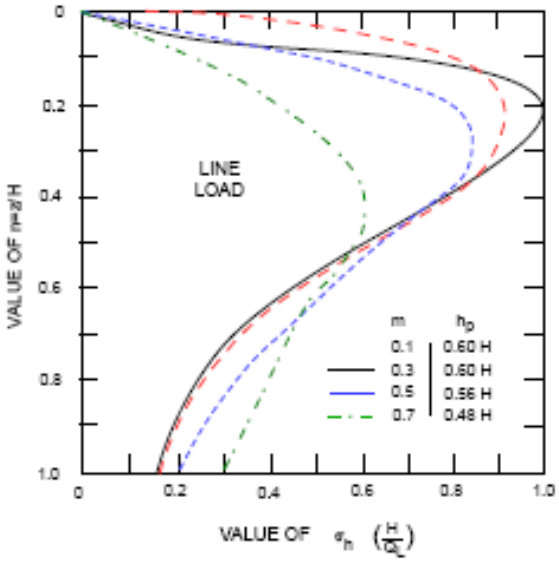
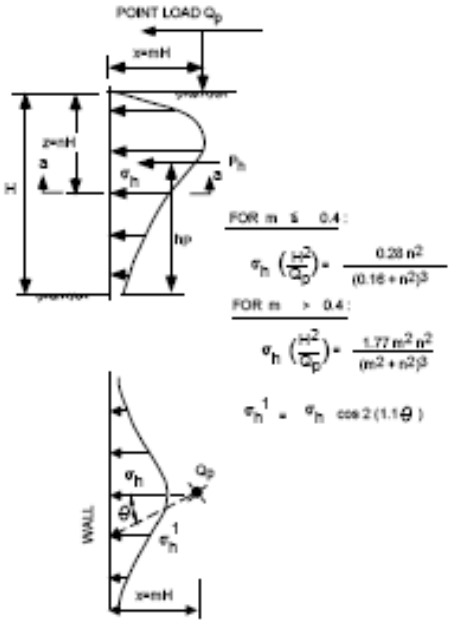
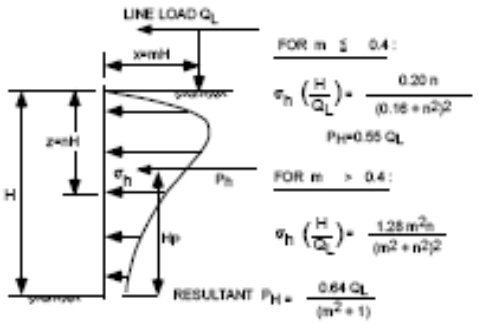
Regional Fault Map
Apple Valley Heights CWD
Water System Improvements
Apple Valley, California
Figure No. 8







SECTION a -a
PRESSURE FROM POINT LOAD Q_p
(BOUSSINESQ EQUATION MODIFIED BY EXPERIMENT)



PRESSURE FROM LINE LOAD Q_L
(BOUSSINESQ EQUATION MODIFIED BY EXPERIMENT)

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Project No: **226817-0000211**
Drawn: **SR**
Date: **May 2018**

Title: **Lateral Surcharge Loads**
Project: **Apple Valley CWD**
Water System Improvements
Apple Valley, California
Figure No. 9

APPENDIX A

Exploratory Test Pit Logs

NV5 BEYOND ENGINEERING

Project: **Apple Valley Heights County Water District**
Project Location: Apple Valley, California
Project Number: 226817-0000211.01

Test Pit TP-1

Sheet 1 of 1

Date(s) Drilled	April 23, 2018	Logged By	Sean Roy, PG 8765	Checked By	Carlos Amante, GE 2724
Drilling Method	Backhoe	Boring Diameter	18-inch bucket with teeth	Approximate Surface Elevation	3,205 feet above mean sea level
Drilling Contractor	Kelley's Underground	Sampling Method	Grab/Bulk	Hammer Data	N/A
Drill Rig Type:	Backhoe	Location: Ocotillo Way and Mesa Vista St		Lat., Long.: 34.427957º, -117.181389º (WGS84)	

Depth (ft)	Sample Type	Blows / 6 in. (N)	Sample ID	USCS Class.	MATERIAL DESCRIPTION	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests and Remarks
0					This log is an integral part of the accompanying report and must be used together with the report for relevant interpretation. The descriptions contained hereon apply only at this boring location and at the time of excavation. Subsurface data are a simplified summary of actual conditions encountered and may vary at other locations and with the passage of time.			
1				SM	ALLUVIUM: Silty SAND (SM): Brown, dry, with fine-medium sand, loose, easy to excavate			CP DS SA
2			Bulk 1					
3								
4				GW	Well-graded GRAVEL (GW): Dry, fine-coarse gravel with subangular rock fragments and well graded sand, easy to moderate effort to excavate			
5			Bag 1	SW	Well-graded SAND (SW): Reddish brown, moist, fine-coarse sand with some gravel, loose, easy to excavate	2.6		
			Bulk 2					
10					Test Pit terminated at a depth 8' below ground surface (bgs) Groundwater not encountered Backfilled with soil cuttings			
15								
20								
25								
30								

CP=Compaction Test; DS=Direct Shear; SA=Sieve Analysis

Sample Type: Cal. Mod. | SPT | Bulk | Other | No Recovery

NV5 BEYOND ENGINEERING

Project: **Apple Valley Heights County Water District**
Project Location: Apple Valley, California
Project Number: 226817-0000211.01

Test Pit TP-2

Sheet 1 of 1

Date(s) Drilled	April 23, 2018	Logged By	Sean Roy, PG 8765	Checked By	Carlos Amante, GE 2724
Drilling Method	Backhoe	Boring Diameter	18-inch bucket with teeth	Approximate Surface Elevation	3,270 feet above mean sea level
Drilling Contractor	Kelley's Underground	Sampling Method	Grab/Bulk	Hammer Data	N/A
Drill Rig Type:	Backhoe	Location: Mesa Vista St ~600 ft South of Ocotillo		Lat., Long.: 34.426428º, -117.181196º (WGS84)	

Depth (ft)	Sample Type	Blows / 6 in. (N)	Sample ID	USCS Class.	MATERIAL DESCRIPTION	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests and Remarks
0					This log is an integral part of the accompanying report and must be used together with the report for relevant interpretation. The descriptions contained hereon apply only at this boring location and at the time of excavation. Subsurface data are a simplified summary of actual conditions encountered and may vary at other locations and with the passage of time.			
1				SM	ALLUVIUM: Silty SAND (SM): Brown, dry, with fine-medium sand, relatively loose, easy to excavate			
2								
3								
4			Bulk 1	SW	Well-graded SAND (SW): Reddish brown, moist, fine-coarse sand with some gravel, loose, easy to excavate			
5						3.2		
				ML	Sandy SILT (ML): Yellowish brown, dry, with very fine sand, firm-hard, moderate effort to excavate			
			Bulk 2					
					Test Pit terminated at a depth 8' below ground surface (bgs) Groundwater not encountered Backfilled with soil cuttings			
10								
15								
20								
25								
30								

Sample Type: Cal. Mod. | SPT | Bulk | Other | No Recovery

NV5 BEYOND ENGINEERING

Project: **Apple Valley Heights County Water District**
Project Location: Apple Valley, California
Project Number: 226817-0000211.01

Test Pit TP-3

Sheet 1 of 1

Date(s) Drilled	April 23, 2018	Logged By	Sean Roy PG, 8765	Checked By	Carlos Amante, GE 2724
Drilling Method	Backhoe	Boring Diameter	18-inch bucket with teeth	Approximate Surface Elevation	3,254 feet above mean sea level
Drilling Contractor	Kelley's Underground	Sampling Method	Grab/Bulk	Hammer Data	N/A
Drill Rig Type:	Backhoe	Location: Mesa Vista Street ~900 ft South of Ocotillo		Lat., Long.: 34.425596, -117.181176 (WGS84)	

Depth (ft)	Sample Type	Blows / 6 in. (N)	Sample ID	USCS Class.	MATERIAL DESCRIPTION	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests and Remarks
					This log is an integral part of the accompanying report and must be used together with the report for relevant interpretation. The descriptions contained hereon apply only at this boring location and at the time of excavation. Subsurface data are a simplified summary of actual conditions encountered and may vary at other locations and with the passage of time.			
0				SM	ALLUVIUM: Silty SAND (SM): Brown, dry, with fine-medium sand, relatively loose, easy to excavate			
1								
2								
3								
4								
5			Bulk 1	SM	Silty SAND with Gravel (SM): Reddish brown, moist, fine-coarse sand with gravel, easy to excavate			SA
						3.3		
				SM	Silty SAND (SM): Yellowish brown, dry, with fine sand, firm-hard, moderate effort to excavate			
10					Test Pit terminated at a depth 8' below ground surface (bgs) Groundwater not encountered Backfilled with soil cuttings			
15								
20								
25								
30								

SA=Sieve Analysis

Sample Type: Cal. Mod. | SPT | Bulk | Other | No Recovery

NV5 BEYOND ENGINEERING

Project: **Apple Valley Heights County Water District**
Project Location: Apple Valley, California
Project Number: 226817-0000211.01

Test Pit TP-4

Sheet 1 of 1

Date(s) Drilled	April 23, 2018	Logged By	Sean Roy PG 8765	Checked By	Carlos Amante, GE 2724
Drilling Method	Backhoe	Boring Diameter	18-inch bucket with teeth	Approximate Surface Elevation	3,191 feet above mean sea level
Drilling Contractor	Kelley's Underground	Sampling Method	Grab/Bulk	Hammer Data	N/A
Drill Rig Type:	Backhoe	Location: Mesa Vista St ~775 ft North of Roundup Way		Lat., Long.: 34.422979º, -117.181186º (WGS84)	

MATERIAL DESCRIPTION

This log is an integral part of the accompanying report and must be used together with the report for relevant interpretation. The descriptions contained hereon apply only at this boring location and at the time of excavation. Subsurface data are a simplified summary of actual conditions encountered and may vary at other locations and with the passage of time.

Depth (ft)	Sample Type	Blows / 6 in. (N)	Sample ID	USCS Class.	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests and Remarks
0					ALLUVIUM:			
1				SP	Poorly-graded SAND (SP): Brown, dry, relatively loose, with fine sand and some fine gravel, easy to excavate			
2								
3								CP
4			Bulk 1	SP	Poorly-graded SAND (SP): Brown, dry, relatively loose, with fine sand and easy to excavate			DS
5								
			Bag 1	SW	Well-graded SAND (SW): Reddish brown, moist, medium dense, fine-coarse sand with some gravel, weakly to moderately cemented, moderate effort to excavate	4.1		
					Test Pit terminated at a depth 8' below ground surface (bgs) Groundwater not encountered Backfilled with soil cuttings			
10								
15								
20								
25								
30								

CP=Compaction Test; DS=Direct Shear

Sample Type: Cal. Mod. | SPT | Bulk | Other | No Recovery

NV5 BEYOND ENGINEERING

Project: **Apple Valley Heights County Water District**
Project Location: Apple Valley, California
Project Number: 226817-0000211.01

Test Pit TP-5

Sheet 1 of 1

Date(s) Drilled	April 23, 2018	Logged By	Sean Roy, PG 8765	Checked By	Carlos Amante, GE 2724
Drilling Method	Backhoe	Boring Diameter	18-inch bucket with teeth	Approximate Surface Elevation	3,227 feet above mean sea level
Drilling Contractor	Kelley's Underground	Sampling Method	Grab/Bulk	Hammer Data	N/A
Drill Rig Type:	Backhoe	Location: Roundup Way & Mesa Vista Street		Lat., Long.: 34.420701º, -117.181132º (WGS84)	

Depth (ft)	Sample Type	Blows / 6 in. (N)	Sample ID	USCS Class.	MATERIAL DESCRIPTION	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests and Remarks
0					This log is an integral part of the accompanying report and must be used together with the report for relevant interpretation. The descriptions contained hereon apply only at this boring location and at the time of excavation. Subsurface data are a simplified summary of actual conditions encountered and may vary at other locations and with the passage of time.			
1				SM	ALLUVIUM: Silty SAND with Gravel (SM): Brown, dry, with silty fine sand, subangular cobbles, and some boulders up to 18 inches, moderate effort to excavate			
2								
3								
4								
5								
			Bulk 1	SM	Silty SAND with Gravel (SM): Brown, dry, with silty fine sand, subangular cobbles, and some boulders up to 18 inches, moderate effort to excavate	1.6		CO
10					Test Pit terminated at a depth 10.5' below ground surface (bgs) Groundwater not encountered Backfilled with soil cuttings			
15								
20								
25								
30								

CO=Corrosivity

Sample Type: Cal. Mod. | SPT | Bulk | Other | No Recovery

NV5 BEYOND ENGINEERING

Project: **Apple Valley Heights County Water District**
Project Location: Apple Valley, California
Project Number: 226817-0000211.01

Test Pit TP-6

Sheet 1 of 1

Date(s) Drilled	April 23, 2018	Logged By	Sean Roy, PG 8765	Checked By	Carlos Amante, GE 2724
Drilling Method	Backhoe	Boring Diameter	18-inch bucket with teeth	Approximate Surface Elevation	3,314 feet above mean sea level
Drilling Contractor	Kelley's Underground	Sampling Method	Grab/Bulk	Hammer Data	N/A
Drill Rig Type:	Backhoe	Location: Rock Hill Drive & Mesa Vista Street		Lat., Long.: 34.417112º, -117.181302º (WGS84)	

Depth (ft)	Sample Type	Blows / 6 in. (N)	Sample ID	USCS Class.	MATERIAL DESCRIPTION	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests and Remarks
0					This log is an integral part of the accompanying report and must be used together with the report for relevant interpretation. The descriptions contained hereon apply only at this boring location and at the time of excavation. Subsurface data are a simplified summary of actual conditions encountered and may vary at other locations and with the passage of time.			
1				SM	ALLUVIUM: Silty SAND with Gravel (SM): Brown, dry, with silty fine sand, subangular cobbles, and some boulders up to 18 inches, moderate effort to excavate			
2								
3								
4								
5			Bulk 1	SP-SM	Poorly-graded SAND with Silt and Gravel (SP-SM): Brown, dry, with silty fine sand, subangular cobbles, and some boulders up to 18 inches, moderate effort to excavate			SA
10					Test Pit terminated at a depth of 8' below ground surface (bgs) Groundwater not encountered Backfilled with soil cuttings			
15								
20								
25								
30								

SA=Sieve Analysis

Sample Type: Cal. Mod. | SPT | Bulk | Other | No Recovery

NV5 BEYOND ENGINEERING

Project: **Apple Valley Heights County Water District**
Project Location: Apple Valley, California
Project Number: 226817-0000211.01

Test Pit TP-7

Sheet 1 of 1

Date(s) Drilled	April 23, 2018	Logged By	Sean Roy, PG 8765	Checked By	Carlos Amante, GE 2724
Drilling Method	Backhoe	Boring Diameter	18-inch bucket with teeth	Approximate Surface Elevation	3,445 feet above mean sea level
Drilling Contractor	Kelley's Underground	Sampling Method	Grab/Bulk	Hammer Data	N/A
Drill Rig Type:	Backhoe	Location: Mesa Vista St ~ 500 feet Southwest of Valley View Road		Lat., Long.: 34.415101º, -117.182104º (WGS84)	

Depth (ft)	Sample Type	Blows / 6 in. (N)	Sample ID	USCS Class.	MATERIAL DESCRIPTION	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests and Remarks
0					This log is an integral part of the accompanying report and must be used together with the report for relevant interpretation. The descriptions contained hereon apply only at this boring location and at the time of excavation. Subsurface data are a simplified summary of actual conditions encountered and may vary at other locations and with the passage of time.			
1			Bulk 1	GM	WEATHERED ROCK: Silty GRAVEL (GM): Brown, dry, with silty fine sand and angular rock fragments, extremely difficult excavating			CO EI
2								
3					Refusal on hard rock at a depth of 2.5' below ground surface (bgs) Groundwater not encountered Backfilled with soil cuttings			
4								
5								
10								
15								
20								
25								
30								

CO=Corrosivity; EI=Expansion Index

Sample Type: Cal. Mod. | SPT | Bulk | Other | No Recovery

NV5 BEYOND ENGINEERING

Project: **Apple Valley Heights County Water District**
Project Location: Apple Valley, California
Project Number: 226817-0000211.01

Test Pit TP-8

Sheet 1 of 1

Date(s) Drilled	April 23, 2018	Logged By	Sean Roy, PG 8765	Checked By	Carlos Amante, GE 2724
Drilling Method	Backhoe	Boring Diameter	18-inch bucket with teeth	Approximate Surface Elevation	3,077 feet above mean sea level
Drilling Contractor	Kelley's Underground	Sampling Method	Grab/Bulk	Hammer Data	N/A
Drill Rig Type:	Backhoe	Location: Pioneer Road ~ 700 ft South of Tussing Ranch Road		Lat., Long.: 34.440684º, -117.181545º (WGS84)	

Depth (ft)	Sample Type	Blows / 6 in. (N)	Sample ID	USCS Class.	MATERIAL DESCRIPTION	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests and Remarks
					This log is an integral part of the accompanying report and must be used together with the report for relevant interpretation. The descriptions contained hereon apply only at this boring location and at the time of excavation. Subsurface data are a simplified summary of actual conditions encountered and may vary at other locations and with the passage of time.			
0			Bulk 1	SM	ALLUVIUM: Silty SAND (SM): Brown, dry, with fine grained sand, relatively loose, easy to excavate			
1								
2								
3								
4			Bulk 2	SW	Well-graded SAND (SW): Reddish brown, dry, fine-coarse sand with fine gravel, weakly to moderately cemented, moderate effort to excavate	3.1		CP DS
5								
					Test pit terminated at a depth of 7' below ground surface (bgs) Groundwater not encountered Backfilled with soil cuttings			
10								
15								
20								
25								
30								

CP=Compaction Test; DS=Direct Shear

Sample Type: Cal. Mod. | SPT | Bulk | Other | No Recovery

NV5 BEYOND ENGINEERING

Project: **Apple Valley Heights County Water District**
Project Location: Apple Valley, California
Project Number: 226817-0000211.01

Test Pit TP-9

Sheet 1 of 1

Date(s) Drilled	April 23, 2018	Logged By	Sean Roy, PG 8765	Checked By	Carlos Amante, GE 2724
Drilling Method	Backhoe	Boring Diameter	18-inch bucket with teeth	Approximate Surface Elevation	3,093 feet above mean sea level
Drilling Contractor	Kelley's Underground	Sampling Method	Grab/Bulk	Hammer Data	N/A
Drill Rig Type:	Backhoe	Location: Tussing Ranch Road ~ 1,000 feet west of Central Road		Lat., Long.: 34.442543º, -117.176080º (WGS84)	

Depth (ft)	Sample Type	Blows / 6 in. (N)	Sample ID	USCS Class.	MATERIAL DESCRIPTION	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests and Remarks
					This log is an integral part of the accompanying report and must be used together with the report for relevant interpretation. The descriptions contained hereon apply only at this boring location and at the time of excavation. Subsurface data are a simplified summary of actual conditions encountered and may vary at other locations and with the passage of time.			
0			Bulk 1	SM	ALLUVIUM: Silty SAND (SM): Brown, dry, with fine grained sand, moderate effort to excavate			
1								
2								
3								
4				SW	Well-graded SAND (SW): Reddish brown, dry, fine-coarse sand with fine gravel, loose, easy to excavate			
5			Bulk 2			2.1		SA
10					Test pit terminated at a depth of 9' below ground surface (bgs) Groundwater not encountered Backfilled with soil cuttings			
15								
20								
25								
30								

SA=Sieve Analysis

Sample Type: Cal. Mod. | SPT | Bulk | Other | No Recovery

NV5 BEYOND ENGINEERING

Project: **Apple Valley Heights County Water District**
Project Location: Apple Valley, California
Project Number: 226817-0000211.01

Test Pit TP-10

Sheet 1 of 1

Date(s) Drilled	April 23, 2018	Logged By	Sean Roy, PG 8765	Checked By	Carlos Amante, GE 2724
Drilling Method	Backhoe	Boring Diameter	18-inch bucket with teeth	Approximate Surface Elevation	3,096 feet above mean sea level
Drilling Contractor	Kelley's Underground	Sampling Method	Grab/Bulk	Hammer Data	N/A
Drill Rig Type:	Backhoe	Location: Houston Street ~ 150 east of Central Road		Lat., Long.: 34.444419º, -117.172151º (WGS84)	

Depth (ft)	Sample Type	Blows / 6 in. (N)	Sample ID	USCS Class.	MATERIAL DESCRIPTION	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests and Remarks
0					This log is an integral part of the accompanying report and must be used together with the report for relevant interpretation. The descriptions contained hereon apply only at this boring location and at the time of excavation. Subsurface data are a simplified summary of actual conditions encountered and may vary at other locations and with the passage of time.			
1				SW	ALLUVIUM: Well-graded SAND (SW): Reddish brown, dry, fine-coarse grained sand, with some fine gravel, silt, and caliche, moderately cemented, moderate to difficult to excavate			
2								
3								
4			Bulk 1	SW	Well-graded SAND (SW): Reddish brown, dry, fine-coarse grained sand, with some fine gravel, silt, and caliche, moderately cemented, moderate to difficult to excavate	4.7		CO
5								
					Test pit terminated at a depth of 6' below ground surface (bgs) Groundwater not encountered Backfilled with soil cuttings			
10								
15								
20								
25								
30								

CO=Corrosivity

Sample Type: Cal. Mod. | SPT | Bulk | Other | No Recovery

EXPLORATORY TEST PIT LOGS

Bulk samples were obtained in the field during our subsurface evaluation. The samples were tagged in the field and transported to our laboratory for observation and testing.

APPENDIX B

Laboratory Test Results

SUMMARY OF LABORATORY TEST RESULTS

In-situ Moisture

The in-situ moisture contents of selected samples obtained from the test borings were evaluated in general accordance with the latest version of D-2216 laboratory test method. The method involves obtaining the moist weight of the sample and then drying the sample to obtain its dry weight. The moisture content is calculated by taking the difference between the wet and dry weights, dividing it by the dry weight of the sample and expressing the result as a percentage. The results of the in-situ moisture content are presented in the following table and on the logs of exploratory borings in Appendix A.

RESULTS OF MOISTURE CONTENT
(ASTM D2216)

Sample Location	In-Situ Moisture Content (percent)	Dry Density (pounds per cubic foot)
TP-1 @ 5.5 feet	2.6	density not determined
TP-2 @ 5 feet	3.2	density not determined
TP-3 @ 6 feet	3.3	density not determined
TP-4 @ 7.5 feet	4.1	density not determined
TP-5 @ 7 feet	1.6	density not determined
TP-8 @ 4 feet	3.1	density not determined
TP-9 @ 5 feet	2.1	density not determined
TP-10 @ 4 feet	4.7	density not determined

Soil Classification

Soils were visually and texturally classified in accordance with the Unified Soil Classification System. Soil classifications are indicated on the logs of the exploratory test pits in Appendix A.

Particle-size Distribution Test

An evaluation of the grain-size distribution of selected soil samples was performed in general accordance with the latest version of ASTM D-422 (including –200 wash). These test results were utilized in evaluating the soil classifications in accordance with the Unified Soil Classification System. Particle size distribution test results are presented on the laboratory test sheets attached in this appendix.

Direct Shear Test

A direct shear test was performed on remolded samples in accordance with ASTM D3080 to evaluate the shear strength characteristics of the on-site materials. The test method consists of placing the soil

sample in the direct shear device, applying a series of normal stresses, and then shearing the sample at the constant rate of shearing deformation. The shearing force and horizontal displacements are measured and recorded as the soil specimen is sheared. The shearing is continued well beyond the point of maximum stress until the stress reaches a constant or residual value. The results of the tests are presented in the following table and attached in this appendix.

RESULTS OF DIRECT SHEAR TEST
(ASTM D3080)

Sample Location	Peak Friction Angle (degrees)	Peak Cohesion (psf)	Ultimate Friction Angle (degrees)	Ultimate Cohesion (psf)	Notes
TP-1 @ 0-4 feet	37	36	33	108	Remolded to 90% of Maximum Dry Density
TP-4 @ 3-5 feet	35	0	35	0	Remolded to 90% of Maximum Dry Density
TP-8 @ 3-5 feet	34	120	34	132	Remolded to 90% of Maximum Dry Density

Expansion Index Test

An expansion index test was performed on a sample of the on-site soils. The test was performed in general accordance with ASTM D4829. The result of the test is presented below and attached in this appendix.

RESULTS OF EXPANSION INDEX TESTS
(ASTM D 4829)

Location	TP-7 @ 1 – 2 ft
Material Type	Silty GRAVEL (GM)
Source	Native
Initial Moisture	10.3
Final Moisture	10.7
Dry Density, pcf	110.4
Saturation, %	53
Expansion Index	6
Potential Expansion	VERY LOW

Soil Corrosivity Tests

Soluble sulfate, chloride, resistively and pH tests were performed in accordance with California Test Methods (CTM) 643, 417 and 422 to assess the degree of corrosivity of the subgrade soils with regard to concrete and normal grade steel.

RESULTS OF CORROSIVITY TESTS
(CTM 643, 417, and 422)

Sample Location	TP-5 @ 6-8 ft	TP-7 @ 1-2 ft	TP-10 @ 3-5 ft
pH	8.4	8.8	8.0
Electrical Resistivity (Ohm-cm)	8100	4400	4100
Soluble Sulfates (ppm)	63	33	510
Soluble Chlorides (ppm)	11	11	11

Maximum Dry Density Test

Maximum dry density tests were performed on samples of the on-site soils. The tests were performed in general accordance with ASTM D1557. The results of these tests are attached in this appendix.

Natural Moisture Report

(ASTM D2216)

Date:	May 15, 2018	Job Number:	226817-0000211.01 PH.07A
Client:	NV5 Infrastructure	Report Number:	6043
Address:	15092 Avenue of Science, Ste. 200	Lab Number:	115902-115917
	San Diego, CA 92128		
Project:	Apple Valley Heights County Water District		
Project Add:	Apple Valley, CA		
Sampled By:	Sean Roy		
Date Sampled	4/23/2018		
Date Rcvd:	4/24/2018		

Lab Number	115902	115903	115905	115907	115909
Pit No.	1	2	3	4	5
Depth, ft.	5.5	5	6	7.5	7
Moisture Content, %	2.6	3.2	3.3	4.1	1.6

Lab Number	115913	115915	115917		
Pit No.	8	9	10		
Depth, ft.	4	5	4		
Moisture Content, %	3.1	2.1	4.7		

Respectfully Submitted,
NV5 West, Inc.

Reviewed by: _____

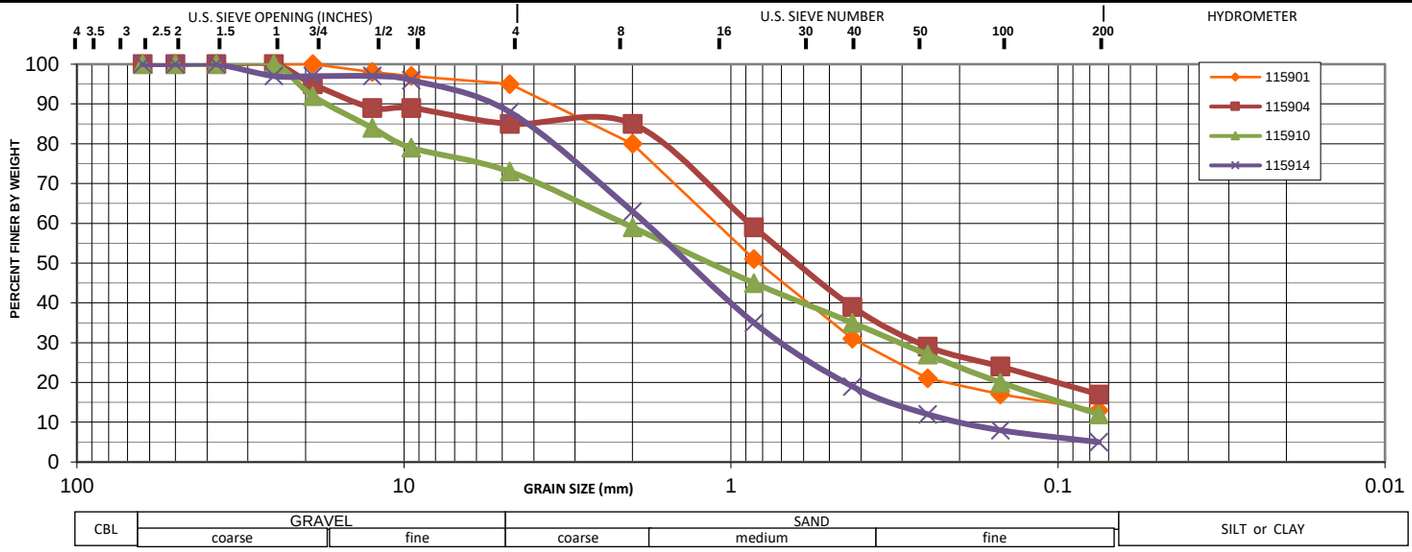
Sammy Daghighi, PE
Senior Engineering Manager

REPORT OF SIEVE ANALYSIS TEST

ASTM D422 - Soil

Date:	May 16, 2018	Job Number:	226817-0000211.01
Client:	NV5 Infrastructure	Report No.:	6043
Address:	15092 Avenue of Science, Ste.200 San Diego, CA 92128	Lab Number:	115901, 115904, 115910, 115914
Project :	Apple Valley Heights County Water District		
Project Address:	Apple Valley, CA		

	115901	115904	115910	115914		
Material	Silty SAND (SM)	Silty SAND with Gravel (SM)	Poorly-graded SAND with Silt and Gravel	Well-graded SAND (SW)		
Color	Brown	Reddish Brown	Reddish Brown	Reddish Brown		
Material Source	Native	Native	Native	Native		
Sample Location	TP-1 @ 0'-4'	TP-3 @ 4'-6'	TP-6 @ 5'-7'	TP-9 @ 3'-9'		
Date Sampled	4/23/2018	4/23/2018	4/23/2018	4/23/2018		
Sampled By	Sean Roy	Sean Roy	Sean Roy	Sean Roy		
Date Tested	5/3/2018	5/8/2018	5/8/2018	5/10/2018		
Tested By	Edwin Ocampo	Edwin Ocampo	Edwin Ocampo	Edwin Ocampo		



Sample ID:	115901	115904	115910	115914		
Sieve Size	% Passing					
63mm (2 1/2")	100	100	100	100		
50mm (2")	100	100	100	100		
37.5mm (1 1/2")	100	100	100	100		
25mm (1")	100	100	100	97		
19mm (3/4")	100	95	92	97		
12.5mm (1/2")	98	89	84	97		
9.5mm (3/8")	97	89	79	96		
4.75mm (#4)	95	85	73	88		
2mm (#10)	80	85	59	63		
850µm (#20)	51	59	45	35		
425µm (#40)	31	39	35	19		
250µm (#60)	21	29	27	12		
150 µm (#100)	17	24	20	8		
75 um (#200) washµ	13	17	12	5		
Fineness Modulus	2.3	2.2	3.0	2.9		
Shape (sand & gravel)	N.R.	N.R.	Round	N.R.		
Hardness (sand & gravel)	N.R.	H&D	N.R.	N.R.		
Specific Gravity	2.65	2.65	2.65	2.65		
Coef. of Curvature (C_C)	13.2	17.4	2.5	2.0		
Coef. of Uniformity (C_U)	89.9	246.7	99.7	10.3		
% Gravel	5	15	27	12		
% Sand	82	68	61	83		
% Fines	13.0	17.0	12.0	5.0		
USCS Class:	SM	SM	SP-SM	SW		

Notes: *Hardness: H&D = Hard & Durable; W&F = Weathered & Friable*
N.R.: Not Recorded; N/A: Not Available.

Respectfully Submitted,
NV5 West, Inc.

Sammy Daghighi, PE
Senior Engineering Manager

DIRECT SHEAR TEST (ASTM D3080)

Project No.	226817-0000211.01 PH07A	Date:	5/15/2018
Client:	NV5 Infrastructure	Report No.:	6043
Proj. Name:	Apple Valley Heights County Water District	Lab No.:	115901
Location:	Apple Valley, CA	Date Rcvd:	4/23/2018
Sample date:	4/23/2018	Sample Location: 0'-4'	Test Pit No. TP-1	Test Date:	5/8/2018

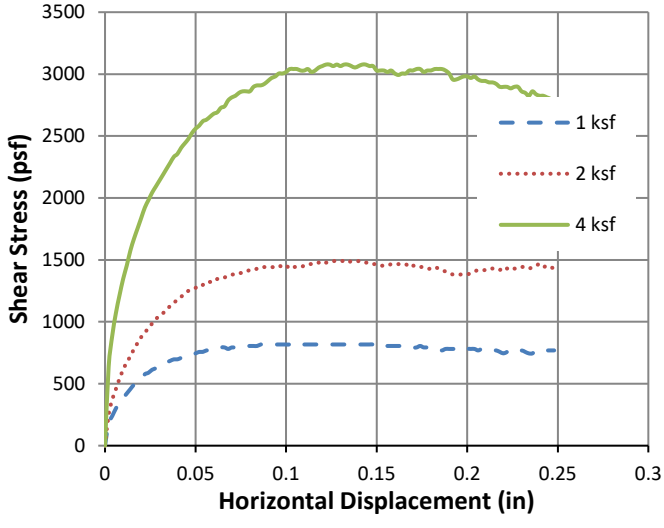
TEST DATA:

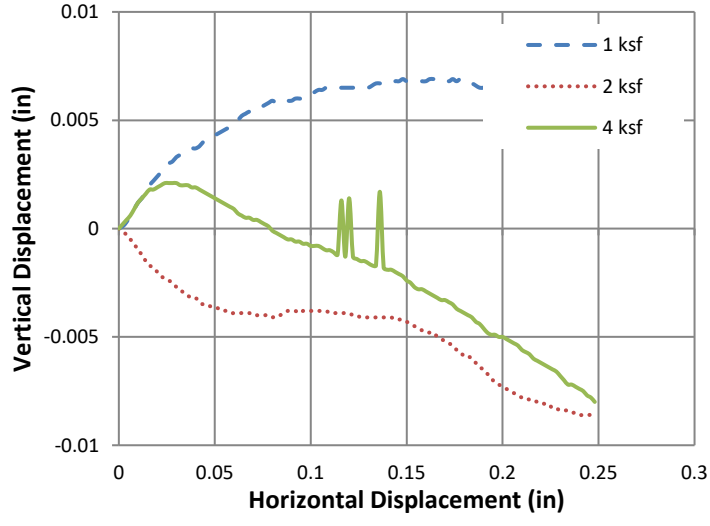
	Sample ID:	1 ksf	2 ksf	4 ksf
Initial	Water Content (%)	7.5	7.5	7.6
	Dry Density	113.7	113.7	113.6
	Saturation (%)	45.7	45.7	45.9
Final	Water Content (%)	17.7	17.4	16.8
	Dry Density	107.2	106.6	108.2
	Saturation (%)	89.8	86.8	87.3
Normal Stress (psf)		1000	2000	4000
Ultimate Shear Stress (psf)		769	1418	2740
Peak Shear Stress (psf)		829	1490	3077

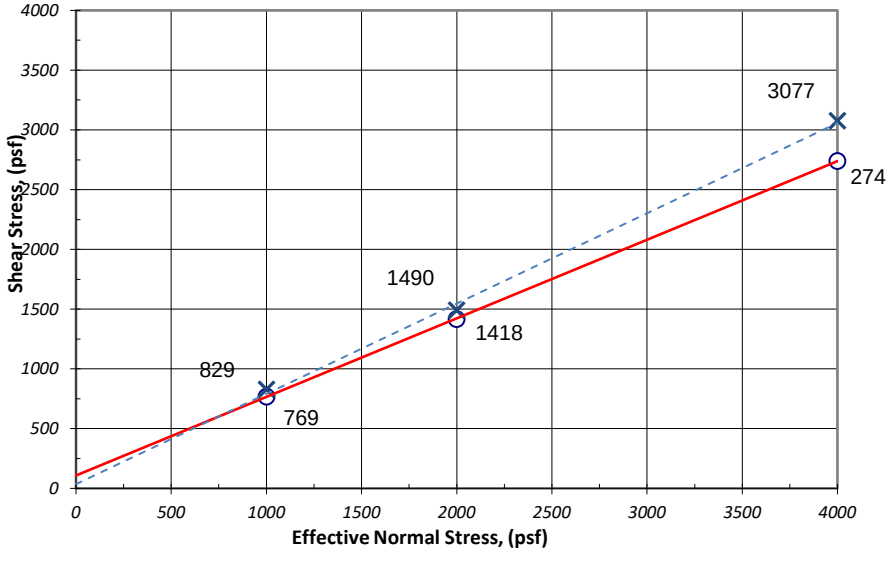
Sample Type: Remolded Sample to 90% of Max Density

Description: Silty SAND (SM)

Color: Brown







Linear (Ultimate Strength Envelope)

Linear (Peak Strength Envelope)

Peak y = 0.7556x + 35.5

Ultimate y = 0.6576x + 108

Peak Cohesion, C'(psf): **36**
Peak Friction,Φ' (deg): **37**

Ultimate Cohesion, C'(psf): **108**
Ultimate Friction,Φ' (deg): **33**

Respectfully Submitted,
NV5 West, Inc.

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15092 Avenue of Science, Ste 200
San Diego CA 92128
p. 858 385 0500 f. 858 715 5810

Sammy Daghighi, PE
Senior Engineering Manager

DIRECT SHEAR TEST (ASTM D3080)

Project No.	**226817-0000211.01 PH07A**	Date:	**5/15/2018**
Client:	**NV5 Infrastructure**	Report No.:	**6043**
Proj. Name:	**Apple Valley Heights County Water District**	Lab No.:	**115906**
Location:	**Apple Valley, CA**	Date Rcvd:	**4/23/2018**
Sample date:	**4/23/2018** Sample Location: **3'-5'** Test Pit No. **TP-4**	Test Date:	**5/14/2018**

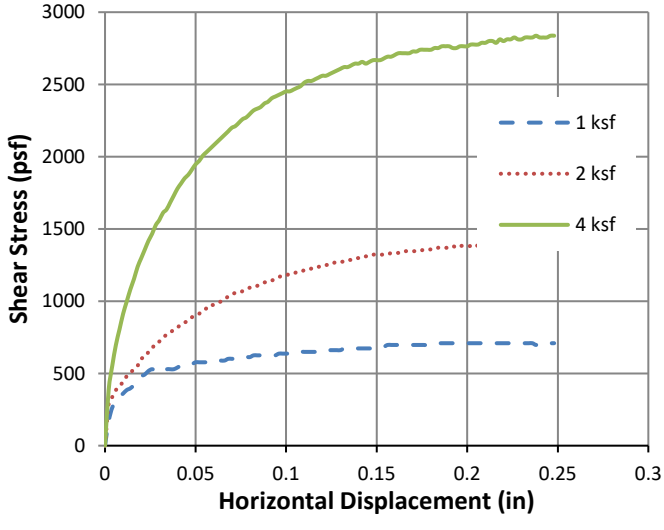
TEST DATA:

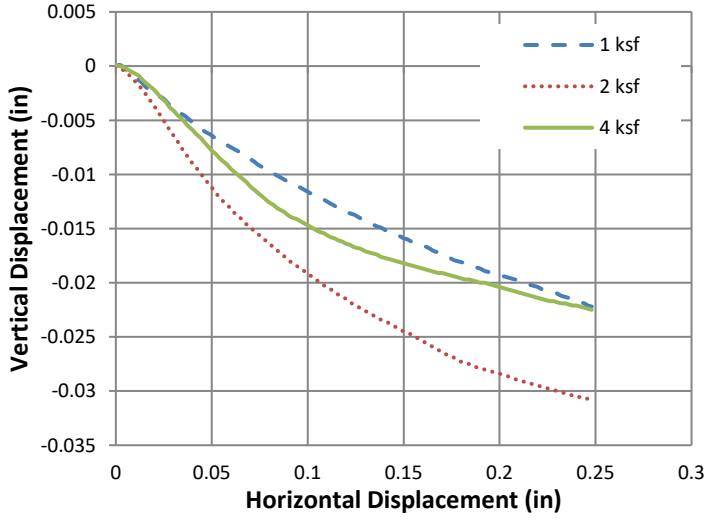
	Sample ID:	1 ksf	2 ksf	4 ksf
Initial	Water Content (%)	9.1	9.1	9.1
	Dry Density	118.3	118.5	118.7
	Saturation (%)	63.6	64.1	64.4
Final	Water Content (%)	17.9	17.4	17.0
	Dry Density	108.7	108.3	109.0
	Saturation (%)	94.3	91.0	90.5
Normal Stress (psf)		1000	2000	4000
Ultimate Shear Stress (psf)		709	1358	2837
Peak Shear Stress (psf)		709	1394	2837

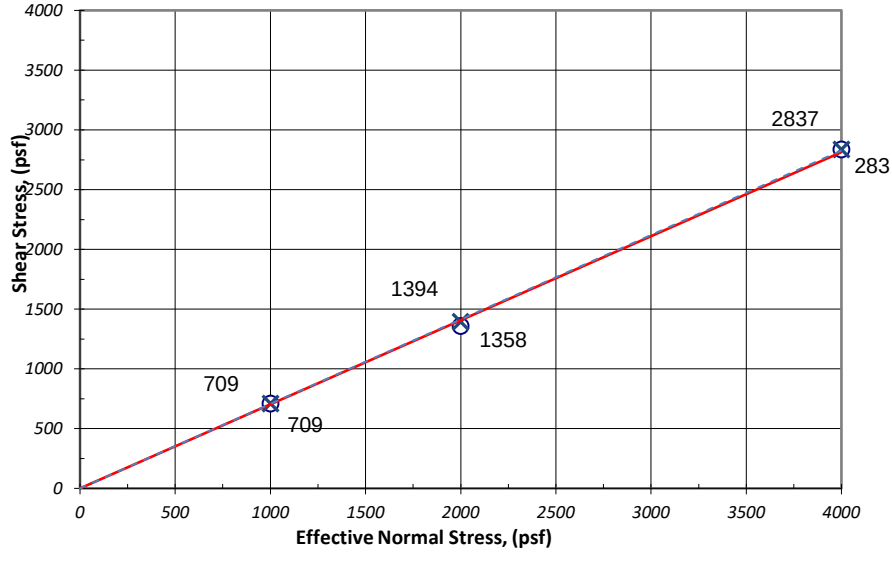
Sample Type: Remolded Sample to 90% of Max Density

Description: Slightly Silty SAND (SP-SM)

Color: Brown







Linear (Ultimate Strength Envelope)

Linear (Peak Strength Envelope)

Peak y = 0.7069x

Ultimate y = 0.7035x

Peak Cohesion, C'(psf): **0**
Peak Friction,Φ' (deg): **35**

Ultimate Cohesion, C'(psf): **0**
Ultimate Friction,Φ' (deg): **35**

Respectfully Submitted,
NV5 West, Inc.

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Sammy Daghighi, PE
Senior Engineering Manager

DIRECT SHEAR TEST (ASTM D3080)

Project No.	**226817-0000211.01 PH07A**	Date:	**5/15/2018**
Client:	**NV5 Infrastructure**	Report No.:	**6043**
Proj. Name:	**Apple Valley Heights County Water District**	Lab No.:	**115912**
Location:	**Apple Valley, CA**	Date Rcvd:	**4/23/2018**
Sample date:	**4/23/2018** Sample Location: **3'-5'** Pit No. **TP-8**	Test Date:	**5/15/2018**

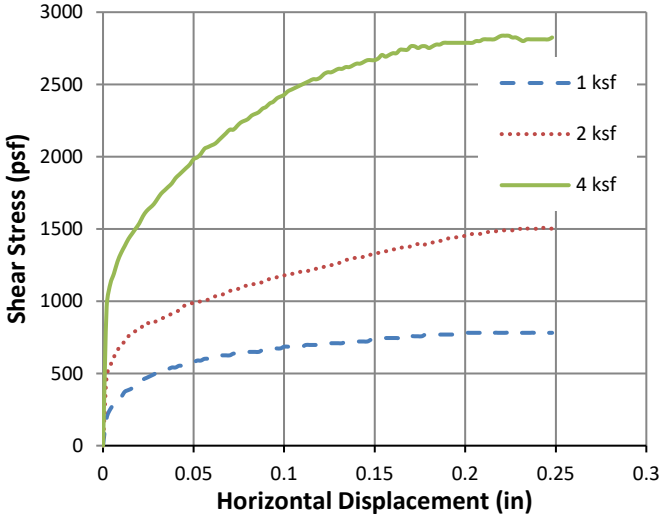
TEST DATA:

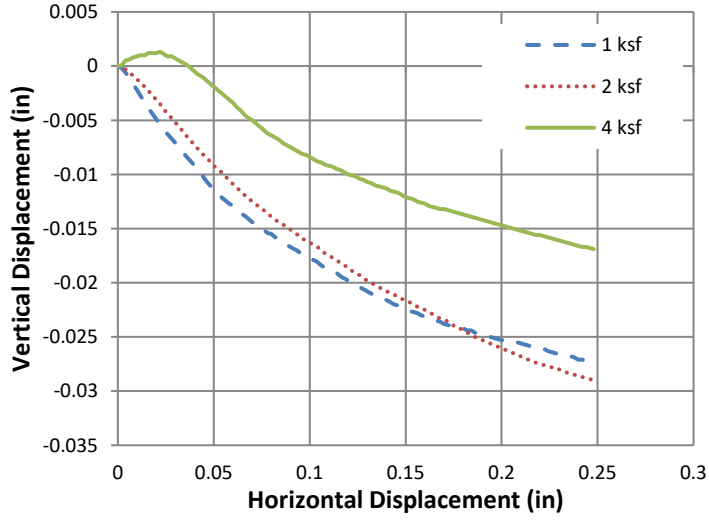
	Sample ID:	1 ksf	2 ksf	4 ksf
Initial	Water Content (%)	7.6	7.6	7.6
	Dry Density	118.5	118.7	119.2
	Saturation (%)	53.4	54.0	54.8
Final	Water Content (%)	15.8	12.1	12.7
	Dry Density	111.1	111.2	111.1
	Saturation (%)	89.3	68.4	71.6
Normal Stress (psf)		1000	2000	4000
Ultimate Shear Stress (psf)		781	1514	2812
Peak Shear Stress (psf)		781	1514	2837

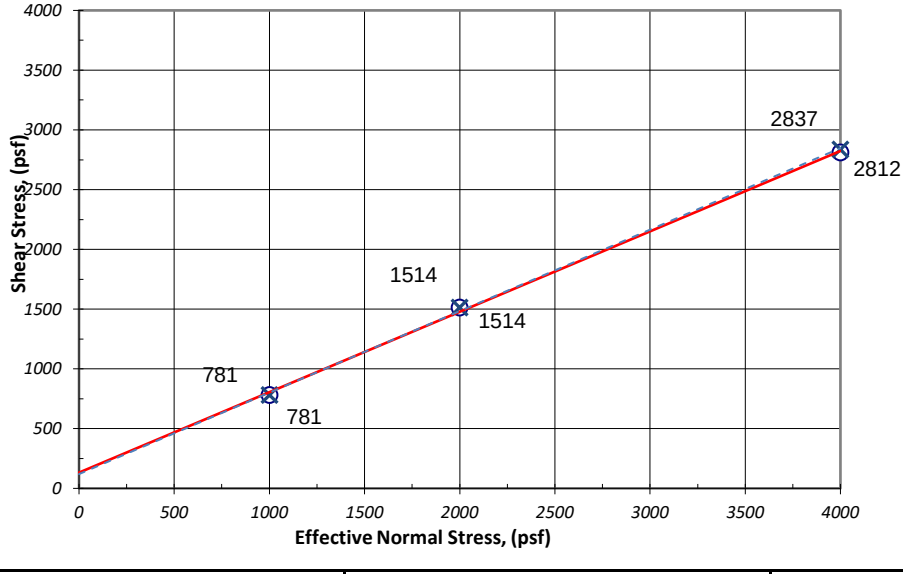
Sample Type: Remolded Sample to 90% of Max Density

Description: Silty SAND (SM)

Color: Reddish Brown







Linear (Ultimate Strength Envelope)

Linear (Peak Strength Envelope)

Peak y = 0.6819x + 119.5

Ultimate y = 0.673x + 132

Peak Cohesion, C'(psf): **120**	Ultimate Cohesion, C'(psf): **132**
Peak Friction,Φ' (deg): **34**	Ultimate Friction,Φ' (deg): **34**

Respectfully Submitted,

NV5 West, Inc.

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San Diego CA 92128
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Sammy Daghighi, PE
Senior Engineering Manager

Expansion Index Test Report

(ASTM D4829)

Date:	May 15, 2018	Job Number:	226817-0000211.01 PH.07A
Client:	NV5 Infrastructure	Report Number:	6043
Address:	15092 Avenue of Science, Ste. 200	Lab Number:	115911
	San Diego, CA 92128		
Project:	Apple Valley Heights County Water District		
Project Add:	Apple Valley, CA		
Sampled By:	Sean Roy		
Date Sampled:	4/23/2018		
Date Rcvd:	4/24/2018		

Lab Number	115911
Location	Pit #7 @ 1'-2'
Material Type	Brown Silty SAND (SM)
Source	Native
Initial Moisture Content, %	10.3
Final Moisture Content, %	10.7
Dry Density, pcf	110.4
Saturation, %	53
Expansion Index	**6**
Potential Expansion	**VERY LOW**

Respectfully Submitted,
NV5 West, Inc.

Sammy Daghighi, PE
Senior Engineering Manager

L A B O R A T O R Y R E P O R T

Telephone (619) 425-1993 Fax 425-7917 Established 1928

C L A R K S O N L A B O R A T O R Y A N D S U P P L Y I N C.
350 Trousdale Dr. Chula Vista, Ca. 91910 www.clarksonlab.com
A N A L Y T I C A L A N D C O N S U L T I N G C H E M I S T S

Date: April 30, 2018
Purchase Order Number: 18-0451
Sales Order Number: 39932
Account Number: NV5-SD
To:
--
NV5 West Inc
15092 Avenue of Science #200
San Diego, CA 92128
Attention: Michelle Albrecht

Laboratory Number: SO6844-1 Customers Phone: 858-715-5800
Fax: 858-715-5810
Sample Designation:
--
One soil sample received on 04/25/18 at 3:00pm,
taken from Job# 226817-0000211.01 Apple Valley Heights
County Water District marked as Lab#115908 Report 6043
Pit #5 6'-8'.

Analysis By California Test 643, 1999, Department of Transportation
Division of Construction, Method for Estimating the Service Life of
Steel Culverts.

pH 8.4

Water Added (ml)	Resistivity (ohm-cm)
10	15000
5	10000
5	8900
5	8100
5	8500
5	9000
5	9200

72 years to perforation for a 16 gauge metal culvert.
94 years to perforation for a 14 gauge metal culvert.
130 years to perforation for a 12 gauge metal culvert.
166 years to perforation for a 10 gauge metal culvert.
202 years to perforation for a 8 gauge metal culvert.

Water Soluble Sulfate Calif. Test 417 0.006% (63ppm)

Water Soluble Chloride Calif. Test 422 0.001% (11ppm)

Laura Torres
LT/ram

L A B O R A T O R Y R E P O R T

Telephone (619) 425-1993 Fax 425-7917 Established 1928

C L A R K S O N L A B O R A T O R Y A N D S U P P L Y I N C.
350 Trousdale Dr. Chula Vista, Ca. 91910 www.clarksonlab.com
A N A L Y T I C A L A N D C O N S U L T I N G C H E M I S T S

Date: April 30, 2018
Purchase Order Number: 18-0451
Sales Order Number: 39932
Account Number: NV5.SD
To:

NV5 West Inc
15092 Avenue of Science #200
San Diego, CA 92128
Attention: Michelle Albrecht

Laboratory Number: SO6844-2 Customers Phone: 858-715-5800
Fax: 858-715-5810
Sample Designation:

One soil sample received on 04/25/18 at 3:00pm,
taken from Job# 226817-0000211.01 Apple Valley Heights
County Water District marked as Lab#115911 Report 6043
Pit #7 1'-2'.

Analysis By California Test 643, 1999, Department of Transportation
Division of Construction, Method for Estimating the Service Life of
Steel Culverts.

pH 8.8

Water Added (ml)	Resistivity (ohm-cm)
100	13000
50	7500
50	5000
50	4600
50	4500
50	4400
50	4800
50	5000

56 years to perforation for a 16 gauge metal culvert.
73 years to perforation for a 14 gauge metal culvert.
101 years to perforation for a 12 gauge metal culvert.
129 years to perforation for a 10 gauge metal culvert.
157 years to perforation for a 8 gauge metal culvert.

Water Soluble Sulfate Calif. Test 417 0.003% (33ppm)

Water Soluble Chloride Calif. Test 422 0.001% (11ppm)

Laura Torres
LT/ram

L A B O R A T O R Y R E P O R T

Telephone (619) 425-1993 Fax 425-7917 Established 1928

C L A R K S O N L A B O R A T O R Y A N D S U P P L Y I N C.
350 Trousdale Dr. Chula Vista, Ca. 91910 www.clarksonlab.com
A N A L Y T I C A L A N D C O N S U L T I N G C H E M I S T S

Date: April 30, 2018
Purchase Order Number: 18-0451
Sales Order Number: 39932
Account Number: NV5.SD
To:
--
NV5 West Inc
15092 Avenue of Science #200
San Diego, CA 92128
Attention: Michelle Albrecht

Laboratory Number: SO6844-3 Customers Phone: 858-715-5800
Fax: 858-715-5810
Sample Designation:
--
One soil sample received on 04/25/18 at 3:00pm,
taken from Job# 226817-0000211.01 Apple Valley Heights
County Water District marked as Lab#115916 Report 6043
Pit #10 3'-5'.

Analysis By California Test 643, 1999, Department of Transportation
Division of Construction, Method for Estimating the Service Life of
Steel Culverts.

pH 8.0

Water Added (ml)	Resistivity (ohm-cm)
10	6300
5	4100
5	4200
5	4600

55 years to perforation for a 16 gauge metal culvert.
71 years to perforation for a 14 gauge metal culvert.
98 years to perforation for a 12 gauge metal culvert.
125 years to perforation for a 10 gauge metal culvert.
153 years to perforation for a 8 gauge metal culvert.

Water Soluble Sulfate Calif. Test 417 0.005% (51ppm)

Water Soluble Chloride Calif. Test 422 0.001% (11ppm)

Laura Torres
LT/ram

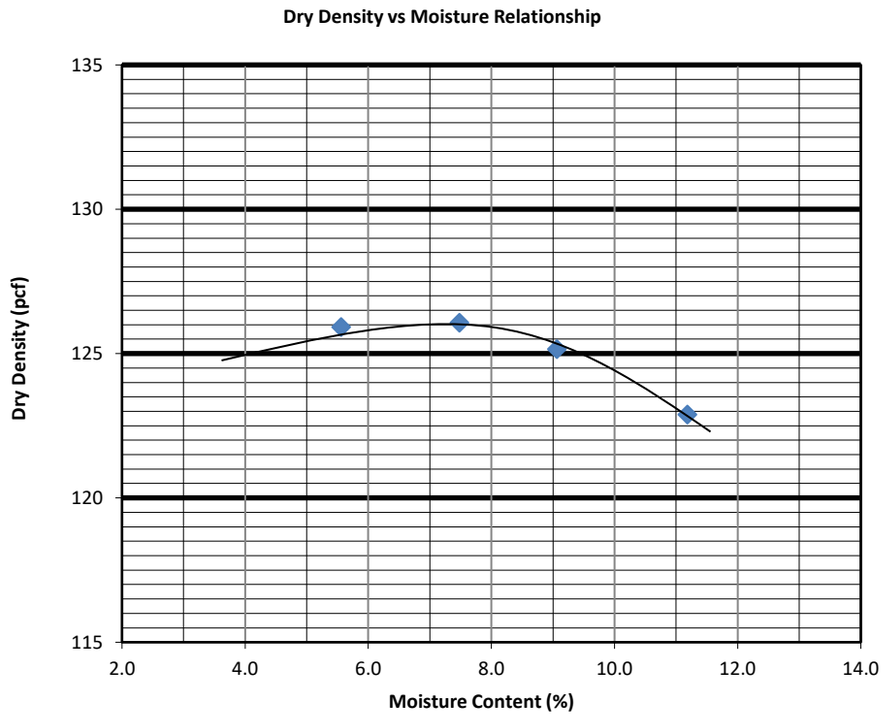
REPORT OF MOISTURE/DENSITY RELATIONSHIP TEST

(ASTM D1557/D698)

Date:	May 16, 2018	Job Number:	226817-0000211.01 PH07A
Client:	NV5 Infrastructure	Report Number:	6043
Address:	15092 Avenue of Science, Ste.200 San Diego, CA 92128	Lab Number:	115901

Project:	Apple Valley Heights County Water District			
Project Address:	Apple Valley, CA			
Material:	Brown Silty SAND (SM)	Mold Size:	4	inch
Material Source:	Native			
Location:	Pit #1 @ 0'-4'	ASTM D1557	B	
Date Sampled:	4/23/2018			
Date Submitted:	4/24/2018			
Sampled By:	Sean Roy			

Maximum Dry Density = 126.0 pcf **Optimum Moisture = 7.5%**



Distribution

Client

File

Reviewed By: _____

Sammy Daghighi, PE

Senior Engineering Manager

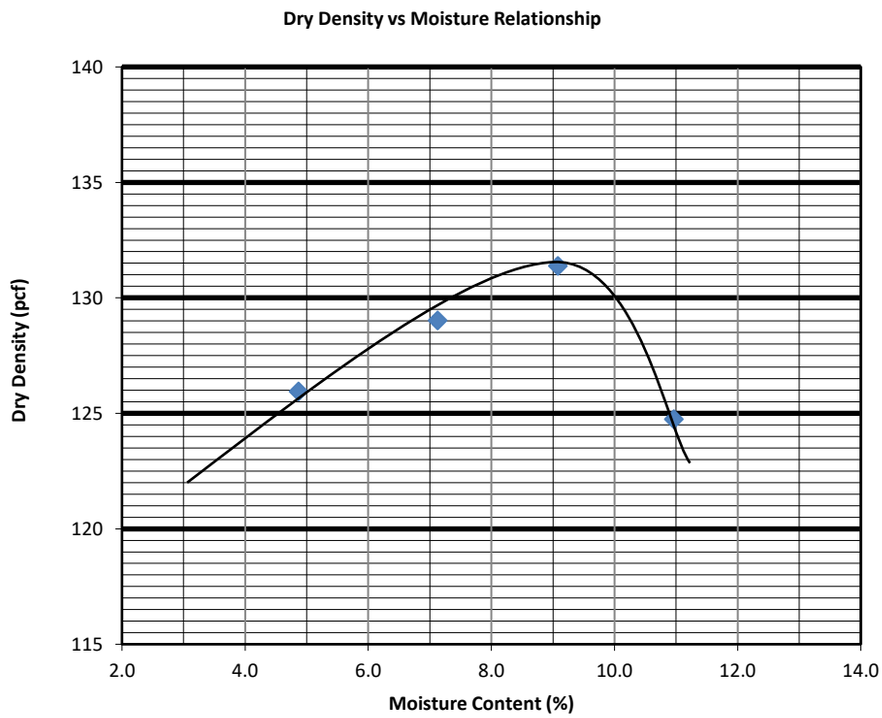
REPORT OF MOISTURE/DENSITY RELATIONSHIP TEST

(ASTM D1557/D698)

Date:	May 16, 2018	Job Number:	226817-0000211.01 PH07A
Client:	NV5 Infrastructure	Report Number:	6043
Address:	15092 Avenue of Science, Ste.200 San Diego, CA 92128	Lab Number:	115906

Project:	Apple Valley Heights County Water District			
Project Address:	Apple Valley, CA			
Material:	Brown Slightly Silty SAND (SP-SM)	Mold Size:	4	inch
Material Source:	Native			
Location:	Pit #4 @ 3'-5'	ASTM D1557	B	
Date Sampled:	4/23/2018			
Date Submitted:	4/24/2018			
Sampled By:	Sean Roy			

Maximum Dry Density = 131.5 pcf **Optimum Moisture = 9.0%**



Distribution

Client

File

Reviewed By: _____

Sammy Daghighi, PE

Senior Engineering Manager

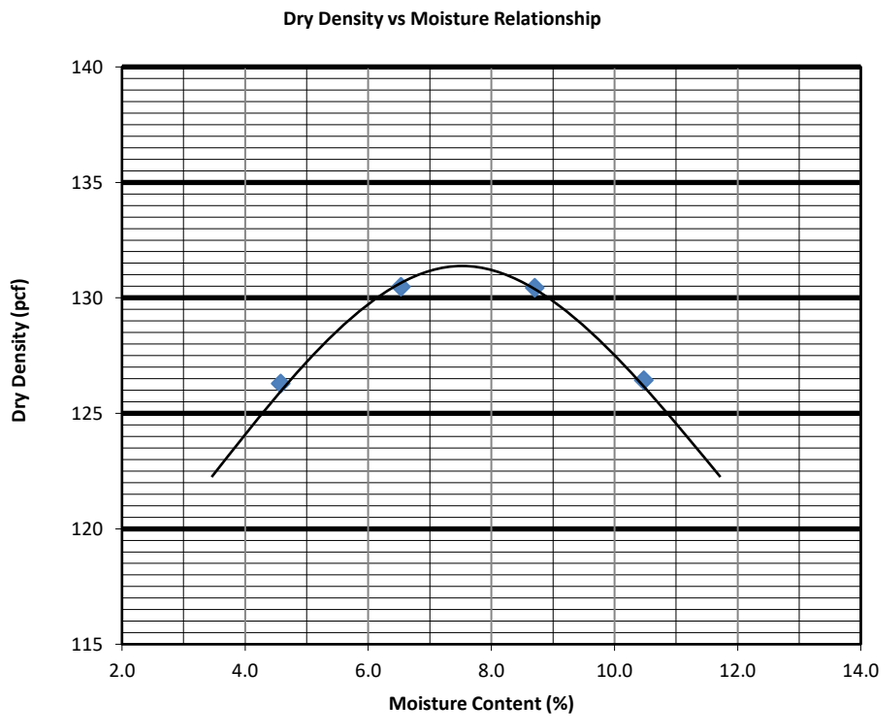
REPORT OF MOISTURE/DENSITY RELATIONSHIP TEST

(ASTM D1557/D698)

Date:	May 16, 2018	Job Number:	226817-0000211.01 PH07A
Client:	NV5 Infrastructure	Report Number:	6043
Address:	15092 Avenue of Science, Ste.200 San Diego, CA 92128	Lab Number:	115912

Project:	Apple Valley Heights County Water District		
Project Address:	Apple Valley, CA		
Material:	Reddish Brown Silty SAND (SM)	Mold Size:	4 inch
Material Source:	Native		
Location:	Pit #8 @ 3'-5'	ASTM D1557	A
Date Sampled:	4/23/2018		
Date Submitted:	4/24/2018		
Sampled By:	Sean Roy		

Maximum Dry Density = 131.5 pcf **Optimum Moisture = 7.5%**



Distribution

Client

File

Reviewed By: _____

Sammy Daghighi, PE

Senior Engineering Manager

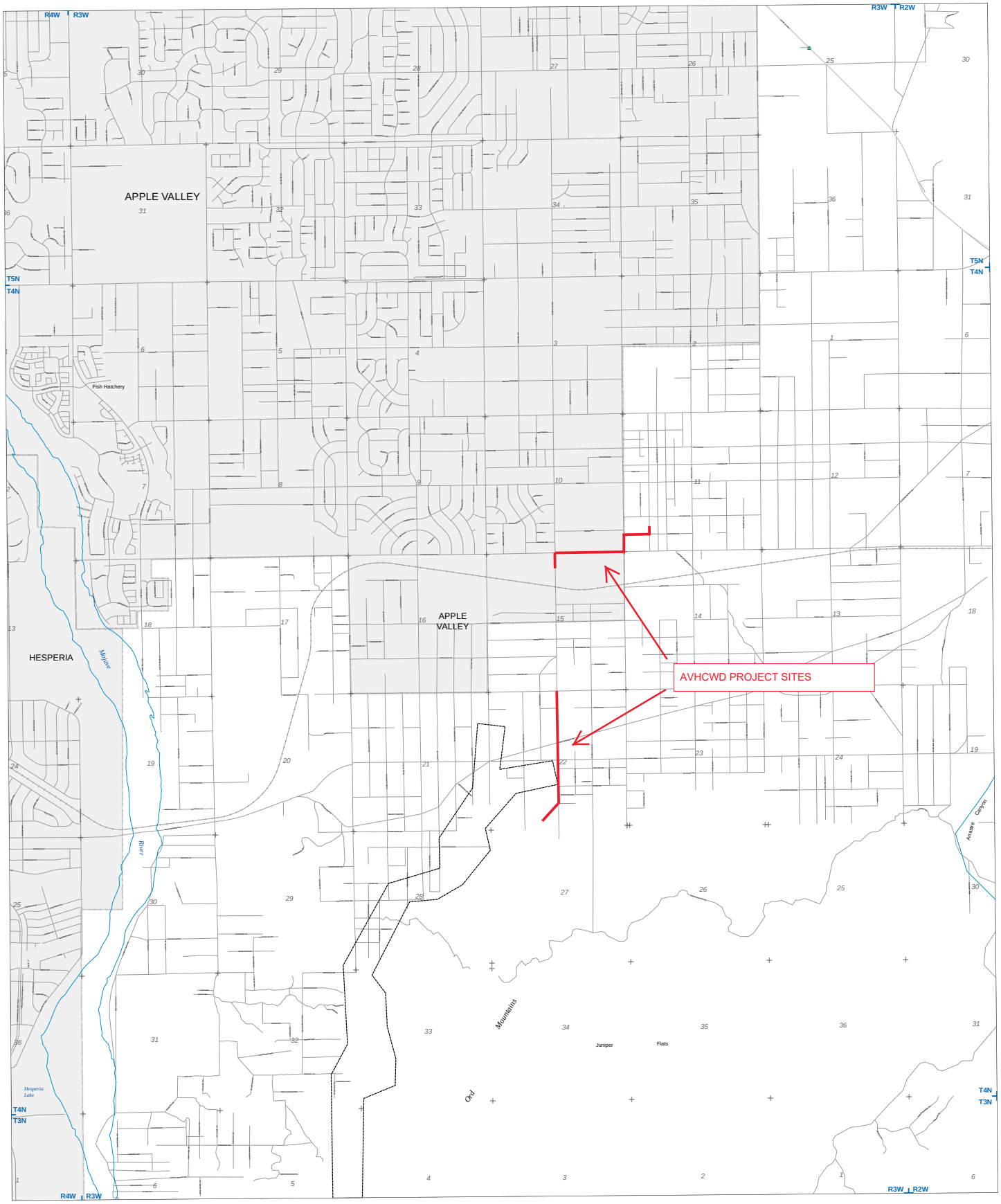
APPENDIX C

San Bernardino County Land Use Plan

GENERAL PLAN

Geologic Hazard Overlays

See EH31 C



See FH03 C

See FH15 C

Proposed AVHCWD Project Sites

San Bernardino County Land Use Plan
GENERAL PLAN
Geologic Hazard Overlays

Generalized Landslide Susceptibility
- Low to moderate
- Moderate to high
- Mapped, Existing Landslide
- Rockfall/Debris-Flow Hazard Area (Forest Falls Only)

Map data originally compiled on 1:48,000 scale mosaicked maps by the State of California, Division of Mines and Geology, U.S. Geological Survey, 1974) and by S.A. Tan, State Division of Mines and Geology, 1989.

Positional accuracy of map data is at best plus or minus 150 feet.

SCALE 1:14,400

Generalized Liquefaction Susceptibility
- Low
- Medium
- High

Map data originally compiled on 1:48,000 scale mosaicked maps by the State of California, 7-1/2 minute USGS quads by J.E. Matti and G.A. Carson, 1988.

Positional accuracy of map data is at best plus or minus 150 feet.

Earthquake Fault Zones
- Earthquake Fault Zone Boundary
- County Designated Fault Zones
- Cities

Map data compiled on 7-1/2 and 15-minute USGS quadrangle maps by the State of California, Division of Mines and Geology, 1987.

Positional accuracy of map data is at best plus or minus 150 feet.

NOTICE:
Effective January 1, 1994, the name "Special Studies Zones" has been changed to "Earthquake Fault Zones" and Chap. 7.5, Div. 2, of the Public Resources Code has been renamed the "Alquist-Priolo Earthquake Fault Zoning Act."

SAN BERNARDINO COUNTY
MAP LOCATION

FH07 C
Apple Valley South

APPENDIX D

Typical Earthwork Guidelines

TYPICAL EARTHWORK GUIDELINES

1. GENERAL

These guidelines and the standard details attached hereto are presented as general procedures for earthwork construction for sites having slopes less than 10 feet high. They are to be utilized in conjunction with the project grading plans. These guidelines are considered a part of the geotechnical report, but are superseded by recommendations in the geotechnical report in the case of conflict. Evaluations performed by the consultant during the course of grading may result in new recommendations which could supersede these specifications and/or the recommendations of the geotechnical report. It is the responsibility of the contractor to read and understand these guidelines as well as the geotechnical report and project grading plans.

1.1. The contractor shall not vary from these guidelines without prior recommendations by the geotechnical consultant and the approval of the client or the client's authorized representative. Recommendations by the geotechnical consultant and/or client shall not be considered to preclude requirements for approval by the jurisdictional agency prior to the execution of any changes.

1.2. The contractor shall perform the grading operations in accordance with these specifications, and shall be responsible for the quality of the finished product notwithstanding the fact that grading work will be observed and tested by the geotechnical consultant.

1.3. It is the responsibility of the grading contractor to notify the geotechnical consultant and the jurisdictional agencies, as needed, prior to the start of work at the site and at any time that grading resumes after interruption. Each step of the grading operations shall be observed and documented by the geotechnical consultant and, where needed, reviewed by the appropriate jurisdictional agency prior to proceeding with subsequent work.

1.4. If, during the grading operations, geotechnical conditions are encountered which were not anticipated or described in the geotechnical report, the geotechnical consultant shall be notified immediately and additional recommendations, if applicable, may be provided.

1.5. An as-graded report shall be prepared by the geotechnical consultant and signed by a registered engineer and registered engineering geologist. The report documents the geotechnical consultants' observations, and field and laboratory test results, and provides conclusions regarding whether or not earthwork construction was performed in accordance with the geotechnical recommendations and the grading plans. Recommendations for foundation design, pavement design, subgrade treatment, etc., may also be included in the as-graded report.

1.6. For the purpose of evaluating quantities of materials excavated during grading and/or locating the limits of excavations, a licensed land surveyor or civil engineer shall be retained.

2. SITE PREPARATION

Site preparation shall be performed in accordance with the recommendations presented in the following sections.

2.1. The client, prior to any site preparation or grading, shall arrange and attend a pre-grading meeting between the grading contractor, the design engineer, the geotechnical consultant, and representatives of appropriate governing authorities, as well as any other involved parties. The parties shall be given two working days notice.

2.2. Clearing and grubbing shall consist of the substantial removal of vegetation, brush, grass, wood, stumps, trees, tree roots greater than 1/2-inch in diameter, and other deleterious materials from the areas to be graded. Clearing and grubbing shall extend to the outside of the proposed excavation and fill areas.

2.3. Demolition in the areas to be graded shall include removal of building structures, foundations, reservoirs, utilities (including underground pipelines, septic tanks, leach fields, seepage pits, cisterns, etc.), and other manmade surface and subsurface improvements, and the backfilling of mining shafts, tunnels and surface depressions. Demolition of utilities shall include capping or rerouting of pipelines at the project perimeter, and abandonment of wells in accordance with the requirements of the governing authorities and the recommendations of the geotechnical consultant at the time of demolition.

2.4. The debris generated during clearing, grubbing and/or demolition operations shall be removed from areas to be graded and disposed of off site at a legal dump site. Clearing, grubbing, and demolition operations shall be performed under the observation of the geotechnical consultant.

2.5. The ground surface beneath proposed fill areas shall be stripped of loose or unsuitable soil. These soils may be used as compacted fill provided they are generally free of organic or other deleterious materials and evaluated for use by the geotechnical consultant. The resulting surface shall be evaluated by the geotechnical consultant prior to proceeding. The cleared, natural ground surface shall be scarified to a depth of approximately 8 inches, moisture conditioned, and compacted in accordance with the specifications presented in Section 5 of these guidelines.

3. REMOVALS AND EXCAVATIONS

Removals and excavations shall be performed as recommended in the following sections.

3.1. Removals

3.1.1. Materials which are considered unsuitable shall be excavated under the observation of the geotechnical consultant in accordance with the recommendations contained herein. Unsuitable materials include, but may not be limited to, dry, loose, soft, wet, organic, compressible natural soils, fractured, weathered, soft bedrock, and undocumented or otherwise deleterious fill materials.

3.1.2. Materials deemed by the geotechnical consultant to be unsatisfactory due to moisture conditions shall be excavated in accordance with the recommendations of the geotechnical consultant, watered or dried as needed, and mixed to generally uniform moisture content in accordance with the specifications presented in Section 5 of this document.

3.2. Excavations

3.2.1. Temporary excavations no deeper than 4 feet in firm fill or natural materials may be made with vertical side slopes. To satisfy California Occupational Safety and Health Administration (CAL OSHA) requirements, any excavation deeper than 4 feet shall be shored or laid back at a 1:1 inclination or flatter, depending on material type, if construction workers are to enter the excavation.

4. COMPACTED FILL

Fill shall be constructed as specified below or by other methods recommended by the geotec1mical consultant. Unless otherwise specified, fill soils shall be compacted to 90 percent relative compaction, as evaluated in accordance with ASTM Test Method D 1557.

4.1. Prior to placement of compacted fill, the contractor shall request an evaluation of the exposed ground surface by the geotechnical consultant. Unless otherwise recommended, the exposed ground surface shall then be scarified to a depth of approximately 8 inches and watered or dried, as needed, to achieve a generally uniform moisture content at or near the optimum moisture content. The scarified materials shall then be compacted to 90 percent relative compaction. The evaluation of compaction by the geotechnical consultant shall not be considered to preclude any requirements for observation or approval by governing agencies. It is the contractor's responsibility to notify the geotechnical consultant and the appropriate governing agency when project areas are ready for observation, and to provide reasonable time for that review.

4.2. Excavated on-site materials which are in general compliance with the recommendations of the geotechnical consultant may be utilized as compacted fill provided they are generally free of organic or other deleterious materials and do not contain rock fragments greater than 6 inches in dimension. During grading, the contractor may encounter soil types other than those analyzed during the preliminary geotechnical study. The geotechnical consultant shall be consulted to evaluate the suitability of any such soils for use as compacted fill.

4.3. Where imported materials are to be used on site, the geotechnical consultant shall be notified three working days in advance of importation in order that it may sample and test the materials from the proposed borrow sites. No imported materials shall be delivered for use on site without prior sampling, testing, and evaluation by the geotechnical consultant.

4.4. Soils imported for on-site use shall preferably have very low to low expansion potential (based on UBC Standard 18-2 test procedures). Lots on which expansive soils may be exposed at grade shall be undercut 3 feet or more and capped with very low to low expansion potential fill. In the event expansive soils are present near the ground surface, special design and construction considerations shall be utilized in general accordance with the recommendations of the geotechnical consultant.

4.5. Fill materials shall be moisture conditioned to near optimum moisture content prior to placement. The optimum moisture content will vary with material type and other factors. Moisture conditioning of fill soils shall be generally uniform in the soil mass.

4.6. Prior to placement of additional compacted fill material following a delay in the grading operations, the exposed surface of previously compacted fill shall be prepared to receive fill. Preparation may include scarification, moisture conditioning, and recompaction.

4.7. Compacted fill shall be placed in horizontal lifts of approximately 8 inches in loose thickness. Prior to compaction, each lift shall be watered or dried as needed to achieve near optimum moisture condition, mixed, and then compacted by mechanical methods, using sheepsfoot rollers, multiple-wheel pneumatic-tired rollers, or other appropriate compacting rollers, to the specified relative compaction. Successive lifts shall be treated in a like manner until the desired finished grades are achieved.

4.8. Fill shall be tested in the field by the geotechnical consultant for evaluation of general compliance with the recommended relative compaction and moisture conditions. Field density testing shall conform to ASTM D 1556-00 (Sand Cone method), D 2937-00 (Drive-Cylinder method), and/or D 2922-96 and D 3017-96 (Nuclear Gauge method). Generally, one test shall be provided for approximately every 2 vertical feet of fin placed, or for approximately every 1000 cubic yards of fill placed. In addition, on slope faces one or more tests shall be taken for approximately every 10,000 square feet of slope face and/or approximately every 10 vertical feet of slope height. Actual test intervals may vary as field conditions dictate. Fill found to be out of conformance with the grading recommendations shall be removed, moisture conditioned, and compacted or otherwise handled to accomplish general compliance with the grading recommendations.

4.9. The contractor shall assist the geotechnical consultant by excavating suitable test pits for removal evaluation and/or for testing of compacted fill.

4.10. At the request of the geotechnical consultant, the contractor shall "shut down" or restrict grading equipment from operating in the area being tested to provide adequate testing time and safety for the field technician.

4.11. The geotechnical consultant shall maintain a map with the approximate locations of field density tests. Unless the client provides for surveying of the test locations, the locations shown by the geotechnical consultant will be estimated. The geotechnical consultant shall not be held responsible for the accuracy of the horizontal or vertical locations or elevations.

4.12. Grading operations shall be performed under the observation of the geotechnical consultant. Testing and evaluation by the geotechnical consultant does not preclude the need for approval by or other requirements of the jurisdictional agencies.

4.13. Fill materials shall not be placed, spread or compacted during unfavorable weather conditions. When work is interrupted by heavy rains, the filling operation shall not be resumed until tests indicate that moisture content and density of the fill meet the project specifications. Regrading of the near-surface soil may be needed to achieve the specified moisture content and density.

4.14. Upon completion of grading and termination of observation by the geotechnical consultant, no further filling or excavating, including that planned for footings, foundations, retaining walls or other features, shall be performed without the involvement of the geotechnical consultant.

4.15. Fill placed in areas not previously viewed and evaluated by the geotechnical consultant may have to be removed and recompacted at the contractor's expense. The depth and extent of removal of the unobserved and undocumented fill will be decided based upon review of the field conditions by the geotechnical consultant.

4.16. Off-site fill shall be treated in the same manner as recommended in these specifications for on-site fills. Off-site fill subdrains temporarily terminated (up gradient) shall be surveyed for future locating and connection.

5. OVERSIZED MATERIAL

Oversized material shall be placed in accordance with the following recommendations.

5.1. During the course of grading operations, rocks or similar irreducible materials greater than 6 inches in dimension (oversized material) may be generated. These materials shall not be placed within the compacted fill unless placed in general accordance with the recommendations of the geotechnical consultant.

5.2. Where oversized rock (greater than 6 inches in dimension) or similar irreducible material is generated during grading, it is recommended, where practical, to waste such material off site, or on site in areas designated as "nonstructural rock disposal areas." Rock designated for disposal areas shall be placed with sufficient sandy soil to generally fill voids. The disposal area shall be capped with a 5-foot thickness of fill which is generally free of oversized material.

5.3. Rocks 6 inches in dimension and smaller may be utilized within the compacted fill, provided they are placed in such a manner that nesting of rock is not permitted. Fill shall be placed and compacted over and around the rock. The amount of rock greater than ¾-inch in dimension shall generally not exceed 40 percent of the total dry weight of the fill mass, unless the fill is specially designed and constructed as a "rock fill."

5.4. Rocks or similar irreducible materials greater than 6 inches but less than 4 feet in dimension generated during grading may be placed in windrows and capped with finer materials in accordance with the recommendations of the geotechnical consultant and the approval of the governing agencies. Selected native or imported granular soil (Sand Equivalent of 30 or higher) shall be placed and flooded over and around the windrowed rock such that voids are filled. Windrows of oversized materials shall be staggered so that successive windrows of oversized materials are not in the same vertical plane. Rocks greater than 4 feet in dimension shall be broken down to 4 feet or smaller before placement, or they shall be disposed of off site.

6. SLOPES

The following sections provide recommendations for cut and fill slopes.

6.1. Cut Slopes

6.1.1. The geotechnical consultant shall observe cut slopes during excavation. The geotechnical consultant shall be notified by the contractor prior to beginning slope excavations.

6.1.2. If, during the course of grading, adverse or potentially adverse geotechnical conditions are encountered in the slope which were not anticipated in the preliminary evaluation report, the geotechnical consultant shall evaluate the conditions and provide appropriate recommendations.

6.2. Fill Slopes

6.2.1. When placing fill on slopes steeper than 5:1 (horizontal:vertical), topsoil, slope wash, colluvium, and other materials deemed unsuitable shall be removed. Near-horizontal keys and near-vertical benches shall be excavated into sound bedrock or fine fill material, in accordance with the recommendation of the geotechnical consultant. Keying and benching shall be accomplished. Compacted fill shall not be placed in an area subsequent to keying and benching until the area has been observed by the geotechnical consultant. Where the natural gradient of a slope is less than 5:1, benching is generally not recommended. However, fill shall not be placed on compressible or otherwise unsuitable materials left on the slope face.

6.2.2. Within a single fill area where grading procedures dictate two or more separate fills, temporary slopes (false slopes) may be created. When placing fill adjacent to a temporary slope, benching shall be conducted in the manner described in Section 7.2. A 3-foot or higher near-vertical bench shall be excavated into the documented fill prior to placement of additional fill.

6.2.3. Unless otherwise recommended by the geotechnical consultant and accepted by the Building Official, permanent fill slopes shall not be steeper than 2:1 (horizontal:vertical). The height of a fill slope shall be evaluated by the geotechnical consultant.

6.2.4. Unless specifically recommended otherwise, compacted fill slopes shall be overbuilt and cut back to grade, exposing firm compacted fill. The actual amount of overbuilding may vary as field conditions dictate. If the desired results are not achieved, the existing slopes shall be overexcavated and reconstructed in accordance with the recommendations of the geotechnical consultant. The degree of overbuilding may be increased until the desired compacted slope face condition is achieved. Care shall be taken by the contractor to provide mechanical compaction as close to the outer edge of the overbuilt slope surface as practical.

6.2.5. If access restrictions, property line location, or other constraints limit overbuilding and cutting back of the slope face, an alternative method for compaction of the slope face may be attempted by conventional construction procedures including backrolling at intervals of 4 feet or less in vertical slope height, or as dictated by the capability of the available equipment, whichever is less. Fill slopes shall be backrolled utilizing a conventional sheepsfoot-type roller. Care shall be taken to maintain the specified moisture conditions and/or reestablish the same, as needed, prior to backrolling.

6.2.6. The placement, moisture conditioning and compaction of fill slope materials shall be done in accordance with the recommendations presented in Section 5 of these guidelines.

6.2.7. The contractor shall be ultimately responsible for placing and compacting the soil out to the slope face to obtain a relative compaction of 90 percent as evaluated by ASTM D 1557 and a moisture content in accordance with Section 5. The geotechnical consultant shall perform field moisture and density tests at intervals of one test for approximately every 10,000 square feet of slope.

6.2.8. Backdrains shall be provided in fill as recommended by the geotechnical consultant.

6.3. Top-of-Slope Drainage

6.3.1. For pad areas above slopes, positive drainage shall be established away from the top of slope. This may be accomplished utilizing a berm and pad gradient of 2 percent or steeper at the top-of-slope areas. Site runoff shall not be permitted to flow over the tops of slopes.

6.3.2. Gunite-lined brow ditches shall be placed at the top of cut slopes to redirect surface runoff away from the slope face where drainage devices are not otherwise provided.

6.4. Slope Maintenance

6.4.1. In order to enhance surficial slope stability, slope planting shall be accomplished at the completion of grading. Slope plants shall consist of deep-rooting, variable root depth, drought-tolerant vegetation. Native vegetation is generally desirable. Plants native to semiarid and mid areas may also be appropriate. Large-leafed ice plant should not be used on slopes. A landscape architect shall be consulted regarding the actual types of plants and planting configuration to be used.

6.4.2. Irrigation pipes shall be anchored to slope faces and not placed in trenches excavated into slope faces. Slope irrigation shall be maintained at a level just sufficient to support plant growth. Property owners shall be made aware that over watering of slopes is detrimental to slope stability. Slopes shall be monitored regularly and broken sprinkler heads and/or pipes shall be repaired immediately.

6.4.3. Periodic observation of landscaped slope areas shall be planned and appropriate measures taken to enhance growth of landscape plants.

6.4.4. Graded swales at the top of slopes and terrace drains shall be installed and the property owners notified that the drains shall be periodically checked so that they may be kept clear. Damage to drainage improvements shall be repaired immediately. To reduce siltation, terrace drains shall be constructed at a gradient of 3 percent or steeper, in accordance with the recommendations of the project civil engineer.

6.4.5. If slope failures occur, the geotechnical consultant shall be contacted immediately for field review of site conditions and development of recommendations for evaluation and repair.

7. TRENCH BACKFILL

The following sections provide recommendations for backfilling of trenches.

7.1. Trench backfill shall consist of granular soils (bedding) extending from the trench bottom to 1 foot or more above the pipe. On-site or imported fill which has been evaluated by the geotechnical consultant may be used above the granular backfill. The cover soils directly in contact with the pipe shall be classified as having a very low expansion potential, in accordance with UBC Standard 18-2, and shall contain no rocks or chunks of hard soil larger than 3/4-inch in diameter.

7.2. Trench backfill shall, unless otherwise recommended, be compacted by mechanical means to 90 percent relative compaction as evaluated by ASTM D 1557. Backfill soils shall be placed in loose lifts 8-inches thick or thinner, moisture conditioned, and compacted in accordance with the recommendations of Section 5 of these guidelines. The backfill shall be tested by the geotechnical consultant at vertical intervals of approximately 2 feet of backfill placed and at spacings along the trench of approximately 100 feet in the same lift.

7.3. Jetting of trench backfill materials is generally not a recommended method of densification, unless the on-site soils are sufficiently free-draining and provisions have been made for adequate dissipation of the water utilized in the jetting process.

7.4. If it is decided that jetting may be utilized, granular material with a sand equivalent greater than 30 shall be used for backfilling in the areas to be jetted. Jetting shall generally be considered for trenches 2 feet or narrower in width and 4 feet or shallower in depth. Following jetting operations, trench backfill shall be mechanically compacted to the specified compaction to finish grade.

7.5. Trench backfill which underlies the zone of influence of foundations shall be mechanically compacted to 90 percent or greater relative compaction, as evaluated by ASTM D 1557-02. The zone of influence of the foundations is generally defined as the roughly triangular area within the limits of a 1:1 (horizontal:vertical) projection from the inner and outer edges of the foundation, projected down and out from both edges.

7.6. Trench backfill within slab areas shall be compacted by mechanical means to a relative compaction of 90 percent, as evaluated by ASTM D 1557. For minor interior trenches, density testing may be omitted or spot testing may be performed, as deemed appropriate by the geotechnical consultant.

7.7. When compacting soil in close proximity to utilities, care shall be taken by the grading contractor so that mechanical methods used to compact the soils do not damage the utilities. If the utility contractors indicate that it is undesirable to use compaction equipment in close proximity to a buried conduit, then the grading contractor may elect to use light mechanical compaction equipment or, with the approval of the geotechnical consultant, cover the conduit with clean granular material. These granular materials shall be jetted in place to the top of the conduit in accordance with the recommendations of Section 8.4 prior to initiating mechanical compaction procedures. Other methods of utility trench compaction may also be appropriate, upon review by the geotechnical consultant and the utility contractor, at the time of construction.

7.8. Clean granular backfill and/or bedding materials are not recommended for use in slope areas unless provisions are made for a drainage system to mitigate the potential for buildup of seepage forces or piping of backfill materials.

7.9. The contractor shall exercise the specified safety precautions, in accordance with OSHA Trench Safety Regulations, while conducting trenching operations. Such precautions include shoring or laying back trench excavations at 1:1 or flatter, depending on material type, for trenches in excess of 5 feet in depth. The geotechnical consultant is not responsible for the safety of trench operations or stability of the trenches.

8. DRAINAGE

The following sections provide recommendations pertaining to site drainage.

8.1. Roof, pad, and slope drainage shall be such that it is away from slopes and structures to suitable discharge areas by nonerodible devices (e.g., gutters, downspouts, concrete swales, etc.).

8.2. Positive drainage adjacent to structures shall be established and maintained. Positive drainage may be accomplished by providing drainage away from the foundations of the structure at a gradient of 2 percent or steeper for a distance of 5 feet or more outside the building perimeter, further maintained by a graded swale leading to an appropriate outlet, in accordance with the recommendations of the project civil engineer and/or landscape architect.

8.3. Surface drainage on the site shall be provided so that water is not permitted to pond. A gradient of 2 percent or steeper shall be maintained over the pad area and drainage patterns shall be established to remove water from the site to an appropriate outlet.

8.4. Care shall be taken by the contractor during grading to preserve any berms, drainage terraces, interceptor swales or other drainage devices of a permanent nature on or adjacent to the property. Drainage patterns established at the time of finish grading shall be maintained for the life of the project. Property owners shall be made very clearly aware that altering drainage patterns may be detrimental to slope stability and foundation performance.

9. SITE PROTECTION

The site shall be protected as outlined in the following sections.

9.1. Protection of the site during the period of grading shall be the responsibility of the contractor unless other provisions are made in writing and agreed upon among the concerned parties. Completion of a portion of the project shall not be considered to preclude that portion or adjacent areas from the need for site protection, until such time as the project is finished as agreed upon by the geotechnical consultant, the client, and the regulatory agency.

9.2. The contractor is responsible for the stability of temporary excavations. Recommendations by the geotechnical consultant pertaining to temporary excavations are made in consideration of stability of the finished project and, therefore, shall not be considered to preclude the responsibilities of the contractor. Recommendations by the geotechnical consultant shall also not be considered to preclude more restrictive requirements by the applicable regulatory agencies.

9.3. Precautions shall be taken during the performance of site clearing, excavation, and grading to protect the site from flooding, ponding, or inundation by surface runoff. Temporary provisions shall be made during the rainy season so that surface runoff is away from and off the working site. Where low areas cannot be avoided, pumps shall be provided to remove water as needed during periods of rainfall.

9.4. During periods of rainfall, plastic sheeting shall be used as needed to reduce the potential for unprotected slopes to become saturated. Where needed, the contractor shall install check dams, desilting basins, riprap, sandbags or other appropriate devices or methods to reduce erosion and provide recommended conditions during inclement weather.

9.5. During periods of rainfall, the geotechnical consultant shall be kept informed by the contractor of the nature of remedial or precautionary work being performed on site (e.g., pumping, placement of sandbags or plastic sheeting, other labor, dozing, etc.).

9.6. Following periods of rainfall, the contractor shall contact the geotechnical consultant and arrange a walk-over of the site in order to visually assess rain-related damage. The geotechnical consultant may also recommend excavation and testing in order to aid in the evaluation. At the request of the geotechnical consultant, the contractor shall make excavations in order to aid in evaluation of the extent of rain-related damage.

9.7. Rain or irrigation related damage shall be considered to include, but may not be limited to, erosion, silting, saturation, swelling, structural distress, and other adverse conditions noted by the geotechnical consultant. Soil adversely affected shall be classified as "Unsuitable Material" and shall be subject to overexcavation and replacement with compacted fill or to other remedial grading as recommended by the geotechnical consultant.

9.8. Relatively level areas where saturated soils and/or erosion gullies exist to depths greater than 1 foot shall be overexcavated to competent materials as evaluated by the geotechnical consultant. Where adverse conditions extend to less than 1 foot in depth, saturated and/or eroded materials may be processed in-place. Overexcavated or in-place processed materials shall be moisture conditioned and compacted in accordance with the recommendations provided in Section 5. If the desired results are not achieved, the affected materials shall be overexcavated, moisture conditioned, and compacted until the specifications are met.

9.9. Slope areas where saturated soil and/or erosion gullies exist to depths greater than 1 foot shall be overexcavated and replaced as compacted fill in accordance with the applicable specifications. Where adversely affected materials exist to depths of I foot or less below proposed finished grade, remedial grading by moisture conditioning in-place and compaction in accordance with the appropriate specifications may be attempted. If the desired results are not achieved, the affected materials shall be overexcavated, moisture conditioned, and compacted until the specifications are met. As conditions dictate, other slope repair procedures may also be recommended by the geotechnical consultant.

9.10. During construction, the contractor shall grade the site to provide positive drainage away from structures and to keep water from ponding adjacent to structures. Water shall not be allowed to damage adjacent properties. Positive drainage shall be maintained by the contractor until permanent drainage and erosion reducing devices are installed in accordance with project plans.

APPENDIX E

GBC Important Information About This Geotechnical Engineering Report

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a civil engineer may not fulfill the needs of a constructor — a construction contractor — or even another civil engineer. Because each geotechnical- engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. No one except you should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply this report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical-engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

Geotechnical Engineers Base Each Report on a Unique Set of Project-Specific Factors

Geotechnical engineers consider many unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk-management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical-engineering report that was:

- not prepared for you;
- not prepared for your project;
- not prepared for the specific site explored; or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical-engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical-engineering report is based on conditions that existed at the time the geotechnical engineer performed the study. *Do not rely on a geotechnical-engineering report whose adequacy may have been affected by*: the passage of time; man-made events, such as construction on or adjacent to the site; or natural events, such as floods, droughts, earthquakes, or groundwater fluctuations. *Contact the geotechnical engineer before applying this report to determine if it is still reliable.* A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ — sometimes significantly — from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide geotechnical-construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are Not Final

Do not overrely on the confirmation-dependent recommendations included in your report. *Confirmation-dependent recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations *only* by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's confirmation-dependent recommendations if that engineer does not perform the geotechnical-construction observation required to confirm the recommendations' applicability.*

A Geotechnical-Engineering Report Is Subject to Misinterpretation

Other design-team members' misinterpretation of geotechnical-engineering reports has resulted in costly

problems. Confront that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Constructors can also misinterpret a geotechnical-engineering report. Confront that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing geotechnical construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical-engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make constructors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give constructors the complete geotechnical-engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise constructors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure constructors have sufficient time* to perform additional study. Only then might you be in a position to give constructors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and constructors fail to recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Environmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform an *environmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold-prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, many mold- prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical- engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; *none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.*

Rely, on Your GBC-Member Geotechnical Engineer for Additional Assistance

Membership in the Geotechnical Business Council of the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you GBC-Member geotechnical engineer for more information.

GEOTECHNICAL BUSINESS COUNCIL
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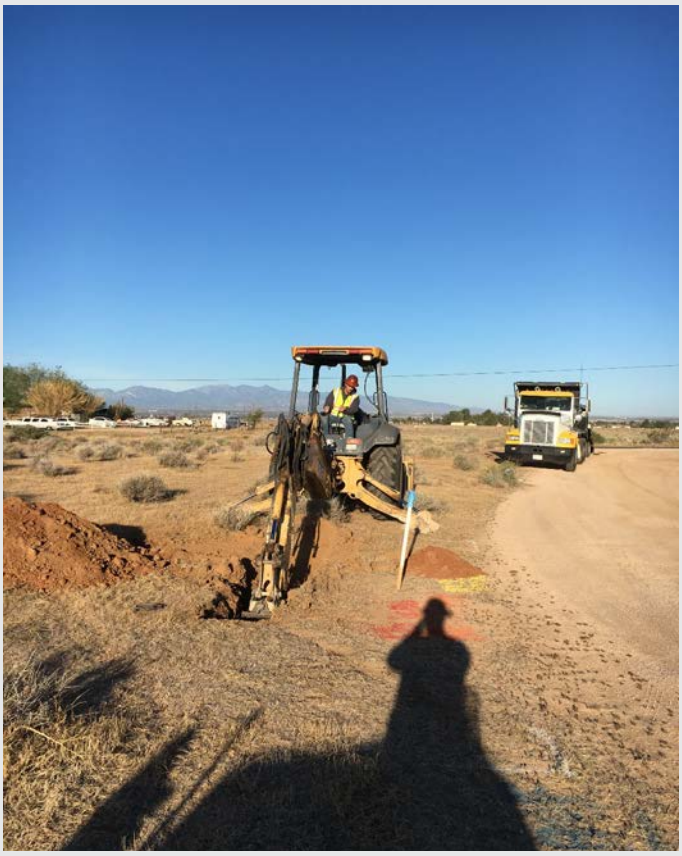

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Delivering Solutions
Improving Lives