PETRA GEOSCIENCES INC.

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PRELIMINARY GEOTECHNICAL EVALUATION REPORT
EAST HIGHLAND RANCH, APPROXIMATELY 12.5-ACRE OF VACANT LAND NORTH OF GREENSPOT ROAD AND BISECTED BY ALTA VISTA
CITY OF HIGHLAND, SAN BERNARDINO COUNTY, CALIFORNIA

DIVERSIFIED PACIFIC COMMUNITIES

AUGUST 12, 2024
J.N. 24-156

ENGINEERS + GEOLOGISTS + ENVIRONMENTAL SCIENTISTS

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August 12, 2024
J.N. 24-156

DIVERSIFIED PACIFIC COMMUNITIES
10621 Civic Center Drive
Rancho Cucamonga, California 91730

Attention: Mr. Jake Sowder

Subject: Preliminary Geotechnical Evaluation Report, *East Highland Ranch*, Approximately 12.5-Acre of Vacant Land North of Greenspot Road and Bisected by Alta Vista, City of Highland, San Bernardino County, California

Dear Mr. Sowder:

In accordance with your request and authorization, **Petra Geosciences, Inc. (Petra)** is submitting this preliminary geotechnical evaluation report for the proposed multi-family residential development in the city of Highland, California.

The purpose of our evaluation was to obtain available geotechnical and geologic information on the nature of current site conditions, to evaluate the potential geologic constraints that may affect development of the property, and to provide recommendations pertaining to site remedial grading and construction of anticipated site improvements. This report presents the results of our preliminary field exploration, limited laboratory testing, engineering judgement, opinions, conclusions, and recommendations pertaining to geotechnical design aspects for the presumed site development.

Should you have questions regarding the contents of this report, or should you require additional information, please contact the undersigned.

Respectfully submitted,

PETRA GEOSCIENCES, INC.

Paul D. Theriault, CEG
Associate Geologist

Offices Strategically Positioned Throughout Southern California
RIVERSIDE COUNTY OFFICE
40880 County Center Drive, Suite M, Temecula, CA 92591
T: 951.600.9271 F: 951.719.1499
For more information visit us online at www.petra-inc.com

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INTRODUCTION

Petra Geosciences, Inc. (Petra) is presenting herein the results of our preliminary geotechnical evaluation for the proposed development of a multi-family residential tract on 12.5-acres located north of Greenspot Road and bisected by Alta Vista, in the city of Highland, California. The purpose of this study was to obtain preliminary information on the general geologic and geotechnical conditions within the project area in order to provide conclusions and recommendations for the feasibility of the proposed project and preliminary geotechnical recommendations for site grading and improvements. Our geotechnical evaluation included a review of geological maps and data for the site and surrounding area, excavation of exploratory test pits, percolation testing, laboratory testing, and geologic and engineering analysis.

SCOPE OF WORK

The scope of our evaluation consisted of the following.

- Review of available published and unpublished data and geotechnical reports concerning geologic and soil conditions within the site and nearby area that could impact on the proposed development.
- Review readily available aerial photographs of the site and surrounding area.
- Excavation, logging, and select sampling of 12 exploratory test pits.
- Perform four percolation tests to aid in evaluating infiltration rates.
- Perform laboratory tests including maximum density at optimum moisture, grain size analyses, expansion index, corrosivity, and remolded shear.
- Preparation of this geotechnical report presenting the results of our analysis and providing recommendations for the proposed site development in general conformance with the requirements of the 2022 California Building Code (2022 CBC) and applicable state and local jurisdictional requirements.

LOCATION AND SITE DESCRIPTION

The irregularly shaped site is situated immediately north of Greenspot Road and bisected by Alta Vista in the city of Highland. The approximately 12.5-acre parcel is currently vacant and bounded by Santa Ana Canyon Road on the north, vacant parcels on the east and west, and Greenspot Road on the south. A Metropolitan Water District (MWD) easement traverses the site from northwest to southeast. Existing improvements within Greenspot Road and Alta Vista were observed to include sewer, water, storm drain, and electrical (street lights). Overhead power lines are present along Santa Ana Canyon Road. A structure associated with the MWD easement was observed at the eastern boundary just north of the easement. Oak Creek, an ephemeral tributary of the Santa Ana River flows southwest just to the east of the site.

A chain-link fence and some debris were observed on the western portion of the property. Sparse shrubs and bushes were observed west of Alta Vista while sparse grasses were observed on the east. The property descends at a low gradient generally towards the west-northwest, with elevations ranging from approximately 1,467 feet above mean sea level (MSL) in the southeast corner to 1,445 feet above MSL in the northwest corner. The surficial soils across the site are generally loose and dry with some cobbles and boulders exposed on the ground surface.

PROPOSED DEVELOPMENT AND GRADING

Conceptual Design, prepared by KTGY Architecture + Planning (2024) indicates the planned development will consist of two- and three-story residential units with attached garages, appurtenant interior alleyways, and drive aisles. Anticipated ancillary site improvements include underground utilities, perimeter walls, storm water basins, a recreation site, and landscaping. Entry to the development will be from Alta Vista. The proposed grading is expected to entail shallow cuts and fills on the order of 2 to 5 feet from existing grades. Appreciable cut or fill slopes are not anticipated.

EVALUATION METHODOLOGY

Literature and Aerial Photo Review

We have reviewed the geotechnical investigation report by RMA GeoScience (RMA, 2015) for the subject site, available online aerial imagery, historic aerial photographs, published geologic maps, and geotechnical literature related to the property and surrounding area (References).

Pertinent findings from our review of RMA's 2015 report are provided below. Clarification to recommendations provided by RMA are presented in parentheses and italics as needed.

RMA Geotechnical Investigation (2015)

- Based on a review of aerial photographs, the site appears to have been vacant dating back to 1938.
- Based on field exploration and analysis, mapping lab testing and geotechnical evaluations, the subject site is geotechnically feasible for the proposed development. The scope of fieldwork included geologic mapping, subsurface exploration with 7 test pits via a backhoe to a maximum depth of 8 feet.

- The site consists of a veneer of topsoil underlain by alluvial fan deposits. Topsoil was approximately 0.5 to 2 feet in depth and consisted of sand with some gravel, cobble, and boulders up to 14 inches in diameter. Alluvial fan deposits generally consisted of sand and gravelly sand with cobbles and some boulders up to 6 feet in diameter. *(Petra: Our field exploration encountered approximately 15-25% more cobbles and boulders.)*

- A review of California Department of Water resource Water Data Library indicates that historic high groundwater is approximately 131 feet below ground surface, as measured in 2011.

- Faults, active or potentially active, are not known to project through the site and the site does not lie within an AP hazard zone. The possibility of damage due to ground rupture is considered low. However, the closest active fault is the San Bernardino strand of the San Andreas fault, located approximately 0.5 miles northeast of the site.

- The potential of damage due to liquefaction is considered nil due to the depth to groundwater.

- Laboratory testing of upper soils indicate a very low expansion potential.

- The existing onsite soils appear to be suitable material for use as fill, provided they are relatively free of rocks larger than 12 inches in maximum dimension, debris and/or organic material. Oversize material greater than 12 inches should be reduced in size or nested a minimum of 10 feet below final grades. (*Petra: Oversize rock should be placed in accordance with our Earthwork Recommendations provided herein.)*

- Following the recommend overexcavation of compressible soils to competent alluvial soils, exposed bottom surface should be scarified to approximately 6 inches, watered to achieve a moisture content of optimum or higher and then compacted in-place to relative compaction of 90 percent or more prior to fill placement.

Field Exploration and Laboratory Testing

Field Exploration

Petra performed a subsurface exploration on March 26, 2024, and included the excavation of 12 exploratory test pits (TP-1 through TP-12) to a maximum depth of 10 feet below the existing ground surface (bgs). Based on the results of our exploratory trenches, the site consists of alluvial fan deposits to the depths explored. A minor amount of artificial fill, likely associated with the construction of Santa Ana Canyon Road and Alta Vista. The alluvial fan deposits consist of sands, gravelly sands, with varying amounts of cobbles and of boulders. As observed during our exploration, the cobble and boulder content (3+ inches in diameter) is estimated to vary between 20 and 60 percent. Test pit logs (Petra, this report; RMA, 2015) are presented in Appendix A. In-situ moisture and density results presented on the boring logs were taken with a nuclear moisture density gauge.

<u>Percolation Testing</u>

Petra performed four percolation tests to evaluate the infiltration rates of the site soils at two proposed basin locations as shown on Figure 2. Methodology and test results are provided in Appendix C

<u>Laboratory Testing</u>

Limited laboratory testing was conducted on various representative undisturbed and bulk soil samples collected from the test pits for engineering properties. Based on the laboratory testing conducted, site soils have a negligible corrosion potential to concrete materials, low exposure to chlorides, and are not considered corrosive with respect to buried metallic elements. Site soils are very sandy and have a very low expansion potential. A summary of the lab results (Petra, this report; RMA, 2015) is included in Appendix B. In-situ dry density and moisture content performed during our site exploration are presented in Appendix A.

FINDINGS

Regional Geologic Setting

The subject property is situated within the northmost portion of the Peninsular Ranges Geomorphic Province (PRGP), near the boundary with the Transverse Ranges Geomorphic Province on the proximal portion of a large alluvial fan that extends southwest from the flanks of the adjacent San Bernardino Mountains to the northeast. The PRGP is composed of series of ranges, separated by northwest trending valleys, subparallel to faults and extends south to Baja California, east to the Colorado Desert, and west into the Pacific Ocean.

Locally, the subject site is located on alluvial fan and active wash deposits emanating from tributaries of the Santa Ana River in the eastern Upper Santa Ana River Valley, causing erosion of the San Bernardino Mountains, located less than one mile to the northeast. The alluvial-fan deposits in the vicinity of the site are on the order of hundreds of feet thick, and composed of silty sands, sands, gravel, cobble, and boulders.

Local Geology and Subsurface Soil Conditions

Earth units encountered within our field evaluation consisted of artificial fill, and alluvial fan deposits. The onsite soil units are discussed in detail below.

- <u>Artificial Fill</u> – Artificial fill was observed overlying alluvial fan deposits in test pits TP-1 and TP-2 to depths of 1.5 to 2.5 feet. These soils were generally composed of silty fine to coarse sand with gravels, cobbles, and boulders, which was light brown to brown, dry, and loose.

- Alluvial Fan Deposits – Alluvial fan deposits were observed beneath the artificial fill and at all test pit locations. The alluvial fan deposits generally consisted of sand to gravelly sand with lesser amounts of sandy gravels with abundant subrounded cobbles and boulders, generally on the order of 20 to 40 percent and occasionally up to 60 percent. These fan deposits were locally weathered and generally loose to medium dense. This unit was non-cohesive and slight caving was observed within all the test pits.

Groundwater

Neither groundwater nor seepage was encountered in the test pits during our subsurface exploration. Based on our review of published geotechnical literature, the depth to groundwater is in excess of 100 feet bgs. Groundwater is not anticipated to affect the proposed development.

Faulting

The geologic structure of the southern California area is dominated mainly by northwest-trending faults associated with the San Andreas system. Active faults in the system include Newport-Inglewood, Whittier, Elsinore, San Jacinto, and San Andreas faults. The San Andreas, Elsinore, and San Jacinto faults have ruptured the ground surface in historic times.

Based on our review of published and unpublished geotechnical maps and literature pertaining to site and regional geology, the closest active fault to the site is the San Bernadino section of the San Andreas fault, approximately 0.62 miles to the northeast. Based on our review of the referenced geologic literature no active faults appear to project through or toward the site, nor does the site lie within an Alquist-Priolo Earthquake Fault Hazard Zone. Additionally, based on historic aerial photos, no lineaments appear to cross or trend towards the property. The potential for active fault rupture at the site is considered to be very low.

Secondary Seismic Effects

Secondary effects of seismic activity normally considered as possible hazards to a site include several types of ground failure. Various general types of ground failures, which might occur due to severe ground shaking at the site include ground subsidence, ground lurching, and lateral spreading. The probability of occurrence of each type of ground failure depends on the severity of the earthquake, distance from faults, topography, subsoil and groundwater conditions, among other factors. The potential for ground lurching and lateral spreading are considered very low.

The potential for seismically induced flooding due to tsunami, seiche (i.e., a wave-like oscillation of the surface of water in an enclosed basin), is considered negligible due to the sites distance from the ocean and closed bodies of water, respectively. Extrapolation of the County of San Bernardino Flood Control District, Seven Oaks Dam, Dam Inundation Based on Dam Breach Map 2 of 7 (References), failure of the Seven Oaks Dam, located approximately 3 miles to the east, would result in inundation in roughly 15 minutes from the breach, with water encompassing the entire site, ranging from approximately 5 feet in the north to 20 feet in the south. These numbers are based on the dam failing while at capacity. To date, the dam has only ever been filled to one-third of its capacity. The dam was built to withstand a magnitude 8.0 earthquake (Orange County Department of Public Works, 2012). Based on the dam's design and limited actual storage (Riverside County Flood Control and Water Conservation District, 2012), the probability of the site becoming inundated is considered very low.

Liquefaction and Seismically-Induced Settlement

Liquefaction is the transformation of a cohesionless soil from a solid to a liquid state caused by an increase in pore pressure and a reduction of effective stress. Liquefaction can occur when loose saturated cohesionless (sandy) soils are subjected to strong ground motion during an earthquake. Typically, liquefaction occurs in areas where groundwater lies within the upper 50 feet of the ground surface. The site is within a San Bernardino County Liquefaction Zone, generally susceptible to medium liquefaction. However, due to the gravelly to cobbly nature of the underlying alluvial-fan materials, as well as the depth to groundwater (expected to be deeper than 100 feet bgs), the potential for liquefaction is considered to be very low. Thus, neither liquefaction nor dynamic settlement should be considered as major geotechnical concerns for site development.

Compressible Near-Surface Soils

A geotechnical factor affecting the project is the presence of low-density and dry, near-surface alluvial fan deposits. Such materials in their present state are not considered suitable for support of fill or structural loads. Accordingly, these materials will require removal to competent alluvial fan deposits as observed by the geotechnical consultant. The unsuitable material may be reused as engineered fill, provided it is placed in accordance with the recommendations provided herein.

CONCLUSIONS AND RECOMMENDATIONS

General

From a geotechnical engineering and engineering geologic point of view, the subject property is considered suitable for the proposed grading and development provided the following conclusions and recommendations are incorporated into the design criteria and project specifications and implemented during construction.

Earthwork Recommendations

General Earthwork Recommendations

Earthwork should be performed in accordance with the Grading Code of the city of Highland and with the applicable provisions of the 2022 California Building Code (2022 CBC), and the site-specific recommendations presented herein.

Geotechnical Observations and Testing

Prior to the start of earthwork, a meeting should be held at the site with the owner, contractor, and geotechnical consultant to discuss the work schedule and geotechnical aspects of the grading. Earthwork, which in this instance will generally entail removal and re-compaction of the near surface soils, should be accomplished under full-time observation and testing of the geotechnical consultant. A representative of the project geotechnical consultant should be present onsite during all earthwork operations to document placement and compaction of fills, as well as to document compliance with the other recommendations presented herein.

Clearing and Grubbing

Clearing operations will include the removal of all existing vegetation, shrubs, stumps any existing dumped trash or construction debris, oversize boulders, undocumented fill, and deleterious materials. All weeds, grasses, bushes, shrubs, tree stumps etc. existing within areas to be graded should be stripped and removed from the site. Any deleterious materials encountered within the site may need to be removed by hand (i.e. by root pickers) during the grading operations.

The project geotechnical consultant should provide periodic observation services during clearing and grubbing operations to document compliance with the above recommendations. In addition, should unusual or adverse soil conditions or buried structures be encountered during grading that are not described herein, these conditions should be brought to the immediate attention of the project geotechnical consultant for corrective recommendations.

Excavation Characteristics

The existing site soils can be readily excavated with conventional earthmoving equipment, however, oversize rocks, those exceeding 12 inches in maximum dimension, are very likely to be encountered during grading.

Ground Preparation

Unsuitable Soil Removals

All existing surficial soils (artificial fill and the upper portions of the alluvial fan deposits) are considered unsuitable in their current state for support of proposed fills, structures, flatwork, pavement, and other improvements. These materials should be removed to underlying competent alluvial fan deposits, as approved by the project geotechnical consultant. Remedial removals are estimated to be approximately 3 to 4 feet below existing grades to expose competent alluvial fan deposits, however, soil removals may also need to be locally deeper depending upon the exposed conditions encountered during grading. The actual depths and horizontal limits of removals and over-excavations should be evaluated during grading by the project geotechnical consultant.

Prior to placing engineered fill, all exposed removal bottom surfaces in the building pad areas should be moisture conditioned (watered or dried) as necessary, to achieve moisture conditions at to slightly above optimum and compacted in-place to a relative compaction of at least 90 percent per ASTM D1557. Horizontal limits of removals should extend across the entire level portion of the lot.

Overexcavation of Cut and Cut-Fill Transition Lots

After removal of unsuitable materials, lots located entirely in cut or cut/fill transitions should be eliminated from building pad areas to reduce the detrimental effects of differential settlement. Cut and cut/fill transition lots should be overexcavated to a minimum of 3 feet below proposed finished pad grade elevations and replaced as properly compacted fill. Prior to placing engineered fill, all exposed overexcavation bottom surfaces in the building pad areas should be moisture conditioned as above, as necessary, to achieve moisture conditions at to slightly above optimum and compacted in-place to a relative compaction of at least 90 percent per ASTM D1557. Horizontal limits of over-excavation should extend across the entire level portion of the lot.

Suitability of Site Soils as Fill

Site soils are suitable for use in engineered fills provided they are clean from any organics, debris, and oversize rocks (greater than 12 inches in diameter). Oversize rocks are likely to be encountered during remedial grading and may be incorporated within specified depths of the engineered fills as discussed in the following section.

Oversize Rock

Removals and over-excavation during grading are expected to produce oversize rock, defined as rock or irreducible rock fragments greater than 12 inches in maximum diameter. Rock less than 12 inches in diameter may be placed as general fill so long as they are placed in a manner to avoid nesting. Oversize rock up greater than 12 inches in diameter may be placed deeper than 5 feet below finished pad grades in a manner to avoid nesting and then completely covered/mixed with granular soil materials. As with the placement of all oversized rock in engineered fills, the granular materials should be watered in a manner to assure the infilling of all voids.

Due to the anticipated relatively shallow fills onsite, i.e., generally expected to be less than 5 feet in depth, exporting of oversize rock greater than 12 inches should be anticipated. The grading contactor should provide either a screening operation to remove oversize rocks from the fill soils or utilize mechanical removal of oversize rocks from the fill areas by heavy equipment equipped with rock rakes or similar equipment.

Fill Placement

Fill materials for building pad areas should be placed in approximately 6- to 8-inch-thick loose lifts, watered or air-dried as necessary to achieve a moisture content at or slightly above optimum moisture, then compacted in-place to a minimum relative compaction of 90 percent. The laboratory maximum dry density and optimum moisture content for each change in soil type should be determined in accordance with ASTM D 1557.

Import Soils for Grading

If imported soils are needed to achieve final design grades, the soils should be free of deleterious materials, oversize rock, and any hazardous materials. Additionally, soils should be non-expansive (i.e., have “very low” expansion potential), non-corrosive, and be approved by the project geotechnical consultant *prior* to being brought onsite.

Soil Shrinkage

Volumetric changes in earth quantities will occur when excavated onsite soils are replaced as engineered fill. Based on similar soil conditions in the nearby area, we estimated the soil shrinkage factor to be on the order of 10 to 15 percent for soil removed and replaced as compacted fill and a subsidence factor of 0.1 foot during recompaction of removal bottoms and overexcavation surfaces. *Also note that volume associated with the removal of oversize rocks greater than 12 inches from the site during planned removals,* *over-excavations, or deep utility trenching should also be accounted for in determining final earthwork quantities*.

The estimate of shrinkage is intended as an aid for project engineers in determining earthwork quantities, however, this estimate should not be considered as absolute values and should be used with some caution. Contingencies should be made for balancing earthwork quantities based on actual shrinkage that occurs during the grading operations.

Temporary Excavations

Temporary excavations up to a depth of 4 feet below existing grades may be required to accommodate the recommended overexcavation. Based on the physical properties of the onsite soils, temporary excavations exceeding 4 feet in height should be cut back to an inclination of 1:1 (h:v) or flatter for the duration of the overexcavation of unsuitable soil material and replacement as compacted fill, as well as placement of underground utilities. It is the responsibility of the contractor and their competent person to ensure that all excavations are constructed in accordance with applicable OSHA guidelines. Other factors to be considered with respect to the stability of the temporary slopes include construction traffic and storage of materials near the tops of slopes, construction scheduling, presence of nearby walls, structures on adjacent properties, and weather conditions at the time of construction.

Geotechnical Observations

Observation of clearing operations, overexcavation of unsuitable surficial materials, fill placement, slope construction, and general grading procedures should be performed by the project geotechnical consultant. Fills should not be placed without prior observation and approval of the removal bottom surfaces by the geotechnical consultant. The project geotechnical consultant or his representative should be present onsite during grading operations to observe and document proper placement and compaction of fill, as well as to observe and document compliance with the other recommendations presented herein.

PRELIMINARY FOUNDATION DESIGN GUIDELINES

Seismic Design Parameters

Earthquake loads on earthen structures and buildings are a function of ground acceleration which may be determined from the site-specific ground motion analysis. Alternatively, a design response spectrum can be developed for certain sites based on the code guidelines. We used two computer applications to provide the design team with the parameters necessary to construct the design acceleration response spectrum for this project. The first was developed by Structural Engineering Association of California (SEA) and California's Office of Statewide Health Planning and Development (OSHPD). The SEA/OSHPD Seismic Design Maps Tool website, https://seismicmaps.org, is used to calculate ground motion parameters. The second, the United Stated Geological Survey (USGS) Unified Hazard Tool website, https://earthquake.usgs.gov/hazards/interactive/, is used to estimate the earthquake magnitude and the distance to surface projection of the fault.

To run the applications discussed above, the following parameters are required: site latitude and longitude; seismic risk category; and site class. The site class designation depends on the direct measurement and the ASCE 7-16 recommended procedure for calculating average small-strain shear wave velocity, Vs30, within the upper 30 meters (approximately 100 feet) of site soils.

A seismic risk category of II was assigned to the proposed building in accordance with 2022 CBC, Table 1604.5. Shear wave velocity measurement were not performed as part of this exploration. However, the subsurface materials at the site exhibit the characteristics of a stiff soil, in accordance with ASCE 7-16, Table 20.3-1 for a Site Class D-Default designation. As such, the following table, Table 1, provides parameters required to construct the seismic response coefficient, C_s, curve based on ASCE 7-16, Article 12.8 guidelines.

TABLE 1

Seismic Design Parameters

Ground Motion Parameters	Specific Reference	Parameter Value	Unit
Site Latitude (North)	-	34.110981	°
Site Longitude (West)	-	-117.150963	°
Site Class Definition	Section 1613.2.2 (1), Chapter 20 (2)	D-Default (4)	-
Assumed Seismic Risk Category	Table 1604.5 (1)	II	-
M_w - Earthquake Magnitude	USGS Unified Hazard Tool (3)	7.9 (3)	-
R – Distance to Surface Projection of Fault	USGS Unified Hazard Tool (3)	1.9(3)	km
S_s - Mapped Spectral Response Acceleration Short Period (0.2 second)	Figure 1613.2.1(1) (1)	2.53 (4)	g
S_1 - Mapped Spectral Response Acceleration Long Period (1.0 second)	Figure 1613.2.1(2) (1)	1.016 (4)	g
F_a – Short Period (0.2 second) Site Coefficient	Table 1613.2.3(1) (1)	1.2 (4)	-
F_v – Long Period (1.0 second) Site Coefficient	Table 1613.2.3(2) (1)	Null (4)	-
S_{MS} – MCE_R Spectral Response Acceleration Parameter Adjusted for Site Class Effect (0.2 second)	Equation 16-36 (1)	3.036 (4)	g
S_{M1} - MCE_R Spectral Response Acceleration Parameter Adjusted for Site Class Effect (1.0 second)	Equation 16-37 (1)	Null (4)	g
S_{DS} - Design Spectral Response Acceleration at 0.2-s	Equation 16-38 (1)	2.024 (4)	g
S_{D1} - Design Spectral Response Acceleration at 1-s	Equation 16-39 (1)	Null (4)	g
$T_o = 0.2\ S_{D1}/ S_{DS}$	Section 11.4.6 (2)	Null	s
$T_s = S_{D1}/ S_{DS}$	Section 11.4.6 (2)	Null	s
T_L - Long Period Transition Period	Figure 22-14 (2)	8 (4)	s
PGA - Peak Ground Acceleration at MCE_G (*)	Figure 22-9 (2)	1.045	g
F_{PGA} - Site Coefficient Adjusted for Site Class Effect (2)	Table 11.8-1 (2)	1.2 (4)	-
PGA_M –Peak Ground Acceleration (2) Adjusted for Site Class Effect	Equation 11.8-1 (2)	1.254 (4)	g
Design PGA ≈ (⅔ PGA_M) - Slope Stability (†)	Similar to Eqs. 16-38 & 16-39 (2)	0.836	g
Design PGA ≈ (0.4 S_{DS}**)** – Short Retaining Walls (‡)	Equation 11.4-5 (2)	0.81	g
C_{RS} - Short Period Risk Coefficient	Figure 22-18A (2)	0.906 (4)	-
C_{R1} - Long Period Risk Coefficient	Figure 22-19A (2)	0.886 (4)	-
SDC - Seismic Design Category (§)	Section 1613.2.5 (1)	Null (4)	-

References:
(1) California Building Code (CBC), 2022, California Code of Regulations, Title 24, Part 2, Volume I and II.
(2) American Society of Civil Engineers/Structural Engineering Institute (ASCE/SEI), 2016, Minimum Design Loads and Associated Criteria for Buildings and Other Structures, Standards 7-16.
(3) USGS Unified Hazard Tool - https://earthquake.usgs.gov/hazards/interactive/
(4) SEI/OSHPD Seismic Design Map Application – https://seismicmaps.org
Related References:
Federal Emergency Management Agency (FEMA), 2015, NEHERP (National Earthquake Hazards Reduction Program) Recommended Seismic Provision for New Building and Other Structures (FEMA P-1050).

Notes:
* PGA Calculated at the MCE return period of 2475 years (2 percent chance of exceedance in 50 years).
† PGA Calculated at the Design Level of ⅔ of MCE; approximately equivalent to a return period of 475 years (10 percent chance of exceedance in 50 years).
‡ PGA Calculated for short, stubby retaining walls with an infinitesimal (zero) fundamental period.
§ The designation provided herein may be superseded by the structural engineer in accordance with Section 1613.2.5.1, if applicable.

Discussion

General

Owing to the characteristics of the subsurface soils, as defined by Site Class D-Default designation, and proximity of the site to the sources of major ground shaking, the site is expected to experience strong ground shaking during its anticipated life span. Under these circumstances, where the code-specified design response spectrum may not adequately characterize site response, the 2022 CBC typically requires a site-specific seismic response analysis to be performed. This requirement is signified/identified by the "null" values that are output using SEAOC/OSHPD software in determination of short period, but mostly, in determination of long period seismic parameters, see Table 1.

For conditions where a "null" value is reported for the site, a variety of analytical design approaches are permitted by 2022 CBC and ASCE 7-16 (see Table 12.6-1)in lieu of a site-specific seismic hazard analysis. For any specific site, these alternative design approaches, which include Equivalent Lateral Force (ELF) procedure, Modal Response Spectrum Analysis (MRSA) procedure, Linear Response History Analysis (LRHA) procedure and Simplified Design procedure, among other methods, are expected to provide results that may or may not be more economical than those that are obtained if a site-specific seismic hazards analysis is performed. These design approaches and their limitations should be evaluated by the project structural engineer.

Seismic Design Category

Please note that the Seismic Design Category, SDC, is also designated as "null" in Table 1. For Risk Category I, II or III structures, where the mapped spectral response acceleration parameter at 1 – second period, S_1, is greater than or equal to 0.75, the 2022 CBC, Section 1613.2.5 requires that these structures be assigned to Seismic Design Category E.

Allowable Bearing Capacity, Estimated Settlement and Lateral Resistance

Allowable Soil Bearing Capacities

Pad Footings

An allowable soil bearing capacity of 1,500 pounds per square foot may be utilized for design of isolated 24-inch-square footings founded at a minimum depth of 12 inches below the lowest adjacent final grade for pad footings that are not a part of the slab system and are used for support of such features as roof overhang, second-story decks, patio covers, etc. This value may be increased by 20 percent for each additional foot of depth and by 10 percent for each additional foot of width, to a maximum value of 2,500 pounds per square foot. The recommended allowable bearing value includes both dead and live loads and may be increased by one-third for short duration wind and seismic forces.

Continuous Footings

An allowable soil bearing capacity of 1,500 pounds per square foot may be utilized for design of continuous footings founded at a minimum depth of 12 inches below the lowest adjacent final grade. This value may be increased by 20 percent for each additional foot of depth and by 10 percent for each additional foot of width, to a maximum value of 2,500 pounds per square foot. The recommended allowable bearing value includes both dead and live loads and may be increased by one-third for short duration wind and seismic forces.

Estimated Footing Settlement

Based on the allowable bearing values provided above, total static settlement of the footings under the anticipated loads is expected to be less than ¾ inch. Differential settlement is expected to be less than ½ inch over a horizontal span of 30 feet. Most of the settlement is likely to take place as footing loads are applied or shortly thereafter.

Lateral Resistance

A passive earth pressure of 250 pounds per square foot per foot of depth, to a maximum value of 2,500 pounds per square foot, may be used to determine lateral bearing resistance for footings. In addition, a coefficient of friction of 0.40 times the dead load forces may be used between concrete and the supporting soils to determine lateral sliding resistance. The above values may be increased by one-third when designing for transient wind or seismic forces. It should be noted that the above values are based on the condition where footings are cast in direct contact with compacted fill or competent native soils. In cases where the footing sides are formed, all backfill placed against the footings upon removal of forms should be compacted to at least 90 percent of the applicable maximum dry density.

Guidelines for Footings and Slabs on-Grade Design and Construction

Near-surface soils within the site will exhibit expansion indices (EI's) that are in the Very Low category (EI $\leq$ 20) following site grading. As indicated in Section 1803.5.3 of 2022 California Building Code (2022 CBC), these soils are considered non-expansive and, as such, the design of slabs on-grade is exempt from the procedures outlined in Sections 1808.6.2 of the 2022 CBC and may be performed using any method deemed rational and appropriate by the project structural engineer. However, the following minimum recommendations are presented herein for conditions where the project design team may require geotechnical engineering guidelines for design and construction of footings and slabs on-grade the project site.

The design and construction guidelines that follow are based on the above soil conditions and may be considered for reducing the effects of variability in fabric, composition and, therefore, the detrimental behavior of the site soils such as excessive short- and long-term total and differential heave or settlement. These guidelines have been developed based on the previous experience of this firm on projects with similar soil conditions. Although construction performed in accordance with these guidelines has been found to reduce post-construction movement and distress, they do not eliminate all potential effects of variability in soils characteristics and future heave or settlement.

It should also be noted that the suggestions for dimension and reinforcement provided herein are performance-based and intended only as preliminary guidelines to achieve adequate performance under the anticipated soil conditions. However, they should not be construed as replacement for structural engineering analyses, experience, and judgment. The project structural engineer, architect or civil engineer should make appropriate adjustments to slab and footing dimensions, and reinforcement type, size and spacing to account for internal (e.g., thermal, shrinkage and expansion) and external (e.g., applied loads) concrete forces as deemed necessary. Consideration should also be given to minimum design criteria as dictated by local building code requirements.

Conventional Slab-on-Grade System

Given the expansion index is expected to be less than 20, we recommend that footings and floor slabs be designed and constructed in accordance with the following minimum criteria.

Footings

1. Exterior continuous footings supporting one- and two-story structures should be founded at a minimum depth of 12 inches below the lowest adjacent final grade, respectively. Interior continuous footings may be founded at a minimum depth of 10 inches below the top of the adjacent finish floor slabs.

2. In accordance with Table 1809.7 of 2022 CBC for light-frame construction, all continuous footings should have minimum widths of 12 inches for one- and two-story construction. We recommend all continuous footings should be reinforced with a minimum of two No. 4 bars, one top and one bottom.

3. A minimum 12-inch-wide grade beam founded at the same depth as adjacent footings should be provided across garage entrances or similar openings (such as large doors or bay windows). The grade beam should be reinforced with a similar manner as provided above.

4. Interior isolated pad footings, if required, should be a minimum of 24 inches square and founded at a minimum depth of 12 inches below the bottoms of the adjacent floor slabs for one- and two-story

buildings. Pad footings should be reinforced with No. 4 bars spaced a maximum of 18 inches on centers, both ways, placed near the bottoms of the footings.

5. Exterior isolated pad footings intended for support of roof overhangs such as second-story decks, patio covers, and similar construction should be a minimum of 24 inches square and founded at a minimum depth of 18 inches below the lowest adjacent final grade. The pad footings should be reinforced with No. 4 bars spaced a maximum of 18 inches on centers, both ways, placed near the bottoms of the footings. Exterior isolated pad footings may need to be connected to adjacent pad and/or continuous footings via tie beams at the discretion of the project structural engineer.

6. The minimum footing dimensions and reinforcement recommended herein may be modified (increased or decreased subject to the constraints of Chapter 18 of the 2022 CBC) by the structural engineer responsible for foundation design based on his/her calculations, engineering experience and judgment.

<u>Building Floor Slabs</u>

1. Concrete floor slabs should be a minimum of 4 inches thick and reinforced with No. 3 bars spaced a maximum of 24 inches on centers, both ways. Alternatively, the structural engineer may recommend the use of prefabricated welded wire mesh for slab reinforcement. For this condition, the welded wire mesh should be of sheet type (not rolled) and should consist of 6x6/W2.9xW2.9 WWF (per the Wire Reinforcement Institute, WRI, designation) or stronger. All slab reinforcement should be properly supported to ensure the desired placement near mid-depth. Care should be exercised to prevent warping of the welded wire mesh between the chairs in order to ensure its placement at the desired mid-slab position.

   Slab dimension, reinforcement type, size and spacing need to account for internal concrete forces (e.g., thermal, shrinkage, and expansion) as well as external forces (e.g., applied loads), as deemed necessary.

2. Living area concrete floor slabs and areas to receive moisture sensitive floor covering should be underlain with a moisture vapor retarder consisting of a minimum 10-mil-thick polyethylene or polyolefin membrane that meets the minimum requirements of ASTM E96 and ASTM E1745 for vapor retarders (such as Husky Yellow Guard®, Stego® Wrap, or equivalent). All laps within the membrane should be sealed, and at least 2 inches of clean sand should be placed over the membrane to promote uniform curing of the concrete. To reduce the potential for punctures, the membrane should be placed on a pad surface that has been graded smooth without any sharp protrusions. If a smooth surface cannot be achieved by grading, consideration should be given to lowering the pad finished grade an additional inch and then placing a 1-inch-thick leveling course of sand across the pad surface prior to the placement of the membrane.

   At the present time, some slab designers, geotechnical professionals, and concrete experts view the sand layer below the slab (blotting sand) as a place for entrapment of excess moisture that could adversely impact moisture-sensitive floor coverings. As a preventive measure, the potential for moisture intrusion into the concrete slab could be reduced if the concrete is placed directly on the vapor retarder. However, if this sand layer is omitted, appropriate curing methods must be implemented to ensure that the concrete slab cures uniformly. A qualified materials engineer with experience in slab design and construction should provide recommendations for alternative methods of curing and supervise the construction process to ensure uniform slab curing. Additional steps would also need to be taken to prevent puncturing of the vapor retarder during concrete placement.

3. Garage floor slabs should be a minimum 4 inches thick and reinforced in a similar manner as living area floor slabs. Garage slabs should also be poured separately from adjacent wall footings with a positive separation maintained using ¾-inch-minimum felt expansion joint material. To control the propagation of shrinkage cracks, garage floor slabs should be quartered with weakened plane joints. Consideration should be given to placement of a moisture vapor retarder below the garage slab, like that provided in Item 2 above, should the garage slab be overlain with moisture sensitive floor covering.

4. Pre-saturation of the subgrade below floor slabs will not be required; however, prior to placing concrete, the subgrade below all dwelling and garage floor slab areas should be thoroughly moistened to achieve a moisture content that is at least equal to or slightly greater than optimum moisture content. This moisture content should penetrate to a minimum depth of 12 inches below the bottoms of the slabs.

5. The minimum dimensions and reinforcement recommended herein for building floor slabs may be modified (increased or decreased subject to the constraints of Chapter 18 of the 2022 CBC) by the structural engineer responsible for foundation design based on his/her calculations, engineering experience and judgment.

Foundation Excavation Observations

Foundation excavations should be observed by a representative of this firm to document that they have been excavated into competent engineered fill soils prior to the placement of forms, reinforcement, or concrete. Following grading, the presence of rock, up to 12 inches diameter, in the compacted fill may result in larger footings than designed and may require the use of forms when pouring concrete. The excavations should be trimmed neat, level, and square. All loose, sloughed or moisture-softened soils and any construction debris should be removed prior to placing of concrete. Excavated soils derived from footing or utility trenches should not be placed in building slab-on-grade areas or exterior concrete flatwork areas unless the soils are compacted to at least 90 percent of maximum dry density.

Foundation Concrete Over-Pour

As noted in the previous section, the on-site soils contain a large percentage of cobbles which will result in widened and potentially deepened footing excavations due to the excavation of rocks in the fill. Even with forming, concrete quantities in excess of calculated footing volumes should be expected.

General Corrosivity Screening

As a screening level study, limited chemical and electrical tests were performed on select samples considered representative of the onsite soils to identify potential corrosive characteristics of these soils. The common indicators associated with soil corrosivity include water-soluble sulfate and chloride levels, pH (a measure of acidity), and minimum electrical resistivity. Test results are presented in Table 2 below and summarized on Plate B-1 in Appendix B.

> *It should be noted that Petra does not practice corrosion engineering; therefore, the test results, opinion and engineering judgment provided herein should be considered general guidelines. Additional analyses would be warranted, especially, for cases where buried metallic building materials (such as copper and cast or ductile iron pipes) in contact with site soils are planned for the project.*
>
> *In many cases, the project geotechnical engineer may not be informed of these choices. Therefore, for conditions where such elements are considered, we recommend that other, relevant project design professionals (e.g., the architect, landscape architect, civil, or structural engineer) also consider recommending a qualified corrosion engineer to conduct additional sampling and testing of near-surface soils during the final stages of site grading to provide a complete assessment of soil corrosivity. Recommendations to mitigate the detrimental effects of corrosive soils on buried metallic and other building materials that may be exposed to corrosive soils should be provided by the corrosion engineer as deemed appropriate.*

In general, a soil's water-soluble sulfate levels and pH relate to the potential for concrete degradation; water-soluble chlorides in soils impact ferrous metals embedded or encased in concrete, e.g., reinforcing steel; and electrical resistivity is a measure of a soil's corrosion potential to a variety of buried metals used in the building industry, such as copper tubing and cast or ductile iron pipes. Table 2, below, presents test results with an interpretation of current code indicators and guidelines that are commonly used in this industry. The table includes the classifications of the soils as they relate to the various tests, as well as a general recommendation for possible mitigation measures in view of the potential adverse impact on various components of the proposed structures in direct contact with site soils. The guidelines provided herein should be evaluated and confirmed, or modified, in their entirety by the project structural engineer, corrosion engineer, or the contractor responsible for concrete placement for structural concrete used in exterior and interior footings, interior slabs on-ground, garage slabs, wall foundations and concrete exposed to weather such as driveways, patios, porches, walkways, ramps, steps, curbs, etc.

TABLE 2

Soil Corrosivity Screening Results

Test	Test Results	Classification	General Recommendations
Soluble Sulfates (Cal 417)	0.0030 percent	S0[1]	Type II cement; min. fc' = 2,500 psi; no water/cement ratio restrictions
pH (Cal 643)	6.4	Neutral	No special requirements
Soluble Chloride (Cal 422)	315 ppm	C1[2] C2[3]	Residence: No special recommendations Pools/Decking: water/cement ratio 0.40, fc' = 5,000 psi
Resistivity (Cal 643)	3,200 ohm-cm	Mildly Corrosive[4]	No special requirements, however, may need to consult a corrosion engineer for sensitive applications.

Notes:
1. ACI 318-14, Section 19.3
2. ACI 318-14, Section 19.3
3. Exposure classification C2 applies specifically to swimming pools and appurtenant concrete elements
4. Pierre R. Roberge, "Handbook of Corrosion Engineering"

Post-Grading Considerations

Precise Grading and Drainage

Surface and subsurface drainage systems consisting of sloping concrete flatwork, drainage swales and possibly subsurface area drains will be constructed on the subject lots to collect and direct all surface water to the adjacent streets. In addition, the ground surface around the proposed buildings should be sloped to provide a positive drainage gradient away from the structures. The purpose of the drainage systems is to prevent ponding of surface water within the level areas of the site and against building foundations and associated site improvements. The drainage systems should be properly maintained throughout the life of the proposed development.

Section 1804.3 of the 2022 CBC requires that "The ground immediately adjacent to the foundation shall be sloped away from the building at a slope of not less than one unit vertical in 20 units horizontal (5-percent slope) for a minimum distance of 10 feet (3048 mm) measured perpendicular to the face of the wall". Further, "Swales used for this purpose shall be sloped a minimum of 2 percent where located within 10 feet (3048 mm) of the building foundation".

These provisions fall under the purview of the Design Civil Engineer. However, exceptions to allow modifications to these criteria are provided within the same section of the Code as "Where climatic or soil conditions warrant, the slope of the ground away from the building foundations is permitted to be reduced to not less than one unit in 48 units horizontal (2-percent slope)". This exemption provision appears to fall under the purview of the Geotechnical Engineer-of-Record.

It is our understanding that the state-of-the-practice for projects in various cities and unincorporated areas of San Bernardino County, as well as throughout Southern California, has been to construct earthen slopes at 2 percent minimum gradient away from the foundations and at 1 percent minimum for earthen swale gradients. Structures constructed and properly maintained under those criteria have performed satisfactorily. Therefore, considering the semi-arid climate, site soil conditions and an appropriate irrigation regime, Petra considers that the implementation of 2 percent slopes away from the structures and 1 percent swales to be acceptable for the subject lots.

It should be emphasized that the homeowners are cautioned that the slopes away from the structures and swales be properly maintained, not be obstructed, and that future improvements do not alter established gradients unless replaced with suitable alternative drainage systems. Further, where the flow line of the swale exists within five feet of the structure, adjacent footings shall be deepened appropriately to maintain minimum embedment requirements, measured from the flow line of the swale.

<u>Utility Trench Backfill</u>

Utility trench backfill should be compacted to a minimum relative compaction of 90 percent. Trench backfill materials should be screened of any rock greater than 6 inches in diameter. The backfill should be placed in 8- to 12-inch lifts, moisture-conditioned as necessary to achieve slightly above optimum moisture conditions and compacted in place to achieve a minimum relative compaction of 90 percent. A representative of this firm should observe and test the backfill to document the adequate compaction has been achieved.

For shallow trenches where pipe or utilities might be damaged by mechanical compaction equipment, imported sand having a Sand Equivalent (SE) value of 30 or greater may be used for backfill. Sand backfill materials should be watered to achieve above optimum moisture conditions, and then tamped with hand-operated pneumatic tampers to ensure proper consolidation of the backfill. No specific relative compaction will be required; however, observation, probing and, if deemed necessary, testing should be performed by a representative of this firm to verify that the backfill is adequately compacted and will not be subject to excessive settlement.

Where a utility trench is proposed in a direction that is parallel to a building footing, the bottom of the trench should not extend below a 1:1 (h:v) plane projected downward from the bottom edge of the adjacent footing. Where this condition occurs, the adjacent footing should be deepened or the trench backfilled and compacted prior to construction of the footing.

Masonry Block Screen Walls

Construction on Level Ground

Where masonry walls are proposed on level ground and 5 feet or more from the tops of descending slopes, the footings may be founded a minimum of 18 inches below the lowest adjacent final grade. Footing trenches should be observed by the project geotechnical representative to document that the footing trenches have been excavated into competent bearing soils and to the recommended embedment. These observations should be performed prior to placing forms or reinforcing steel. The footings should be reinforced with two No. 4 bars, one top and one bottom. The footings should be placed monolithically with continuous rebars to serve as effective "grade beams" along the full lengths of the walls.

Construction Joints

To reduce the potential for cracking related to the effects of differential settlement, positive separations (construction joints) should be provided in the walls at horizontal intervals of approximately 20 to 25 feet and at each corner. The separations should be provided in the blocks only and not extend through the footings.

Retaining Walls

Footing Embedment

The base of retaining wall footings constructed on level ground may be founded a minimum of 12 inches below the lowest adjacent final grade. Footing trenches should be observed by the project geotechnical representative to document that the footing trenches have been excavated into competent bearing soils and to the recommended embedment. These observations should be performed prior to placing forms or reinforcing steel. The footings should be reinforced with two No. 4 bars, one top and one bottom. The footings should be placed monolithically with continuous rebars to serve as effective "grade beams" along the full lengths of the walls.

Allowable Soil Bearing Capacity

An allowable soil bearing capacity of 1,500 pounds per square foot, including dead and live loads, may be utilized for design of 12-inch-wide continuous footings founded in compacted fill at a minimum depth of 12 inches below the lowest adjacent final grade. This value may be increased by 20 percent for each additional foot of depth and by 10 percent for each additional foot of width to a maximum value of 2,500 pounds per square foot. Recommended allowable bearing values include both dead and live loads and may be increased by one-third for short duration wind and seismic forces.

Lateral Resistance

A passive earth pressure of 250 pounds per square foot per foot of depth, to a maximum value of 2,500 pounds per square foot, may be used to determine lateral bearing resistance for footings. In addition, a coefficient of friction of 0.40 times the dead load forces may be used between concrete and the supporting soils to determine lateral sliding resistance. When calculating passive resistance, the resistance of the upper 6 inches of the soil cover in front of the wall should be ignored in areas where the front of the wall will not be covered with concrete flatwork. The above values may be increased by one-third when designing for transient wind or seismic forces. It should be noted that the above values are based on the condition where footings are cast in direct contact with compacted fill or competent native soils. In cases where the footing sides are formed, all backfill placed against the footings upon removal of forms should be compacted to at least 90 percent of the applicable maximum dry density.

Active Earth Pressures

Existing site soils exhibit expansion potentials that are very low in expansion potential; therefore, the proposed retaining walls are expected to be backfilled with on-site soils. Retaining wall plans should specify the type of backfill to be used by the project structural engineer.

On-Site Soils Used for Backfill

On-site soils used for retaining wall backfill should use an active lateral earth pressure equivalent to a fluid having a density of 35 pounds per cubic foot (pcf) for design of cantilevered walls retaining a drained level backfill. Where the wall backfill slopes upward at 2:1 (h:v), the above value should be increased to 51 pcf.

All wall backfill soils should be screened of rock particles greater than 6-inches in diameter. The values provided herein are for retaining walls that have been supplied with a proper subdrain system (see Figure RW-1). Retaining walls should be designed to resist surcharge loads imposed by other nearby walls or structures in addition to the above active earth pressures.

Geotechnical Observation and Testing

All earthwork associated with retaining wall construction, including backcut excavations, observation of the footing trenches, installation of the backdrain systems, and placement of backfill should be provided by a representative of the project geotechnical consultant.

Backdrains

To reduce the likelihood of the entrapment of water in the backfill soils, weepholes or open vertical masonry joints may be considered for retaining walls not exceeding a height of 3 feet. Weepholes, if used, should be 3-inches minimum diameter and provided at maximum intervals of 6 feet along the wall. Open vertical masonry joints, if used, should be provided at 32-inch intervals. A continuous gravel fill, 3 inches by 12 inches, should be placed behind the weepholes or open masonry joints. The gravel should be wrapped in filter fabric to prevent infiltration of fines and subsequent clogging of the gravel. Filter fabric should consist of Mirafi 140N or equivalent.

A perforated pipe-and-gravel subdrain should be constructed behind retaining walls exceeding a height of 3 feet (see Figure RW-1). Perforated pipe should consist of 4-inch-minimum diameter PVC Schedule 40, or ABS SDR-35, with the perforations laid down. The pipe should be encased in a 1-foot-wide column of ¾-inch to 1½-inch open-graded gravel. If on-site soils are used as backfill, the open-graded gravel should extend above the wall footings to a minimum height equal to one-third the wall height or to a minimum height of 1.5 feet above the footing, whichever is greater. The open-graded gravel should be completely wrapped in filter fabric consisting of Mirafi 140N or equivalent. Solid outlet pipes should be connected to the subdrains and routed to a suitable area for discharge of accumulated water.

Waterproofing

The backfilled sides of retaining walls should be coated with an approved waterproofing compound or covered with a similar material to inhibit migration of moisture through the walls.

Wall Backfill

Recommended active pressures for design of retaining walls are based on the physical and mechanical properties of the onsite soil materials. The backfill behind the proposed retaining walls should be screened of rock fragments greater than 6-inches in diameter, placed in approximately 6- to 8-inch-thick maximum lifts, watered as necessary to achieve slightly above optimum moisture conditions, and then mechanically compacted in place to a minimum relative compaction of 90 percent. Flooding or jetting of the backfill materials should be avoided. A representative of the project geotechnical consultant should observe the backfill procedures and test the wall backfill to verify adequate compaction.

Preliminary Pavement Section

Onsite soils are granular and testing within adjacent developments have resulted in R-values over 50. Based on an assumed traffic index of 5.5 and utilizing a preliminary design R-Value of 50, the recommended preliminary pavement sections for the in-tract streets is 3 inches of asphalt concrete over 3.5 inches of aggregate base on properly compacted subgrade soils. R-value testing and final pavement design recommendations should be conducted based on the as-graded conditions at the conclusion grading operations and wet utility trench backfill placement.

The upper 12 inches of subgrade soil immediately below the aggregate base should be compacted to a minimum relative compaction of 95 percent based on ASTM D1557 approximately two percent above optimum moisture content. Final subgrade compaction should be performed prior to placing base materials and after utility-trench backfills have been compacted and tested. Asphaltic concrete materials and construction should conform to Section 203 of the Greenbook or by City of Highland specifications.

Exterior Concrete Flatwork

General

Near-surface compacted fill soils within the site are expected to exhibit an expansion index of 0 to 20, i.e., non-expansive. We recommend that all exterior concrete flatwork such as sidewalks, patio slabs, large decorative slabs, concrete subslabs that will be covered with decorative pavers, vehicular driveways, and access roads within and adjacent to the site, be designed by the project architect or structural engineer with consideration given to mitigating the potential cracking and uplift that can develop in soils exhibiting expansion index values that fall in the very low category. The guidelines that follow should be considered as minimums and are subject to review and revision by the project architect, structural engineer, or landscape consultant as deemed appropriate.

Thickness and Joint Spacing

To reduce the potential of cracking, concrete walkways, patio-type slabs, large decorative slabs and concrete subslabs to be covered with decorative pavers should be at least 4 inches thick and provided with construction joints or expansion joints every 6 feet or less. Private driveways that will be designed for the use of passenger cars for access to private garages should also be at least 4 inches thick and provided with construction joints or expansion joints every 10 feet or less. Concrete pavement that will be designed based on an unlimited number of applications of an 18-kip single-axle load in public access areas, segments of road that will be paved with concrete (such as bus stops and cross-walks) or access roads and driveways, which serve multiple residential units or garages, which will be subject to heavy truck loadings should have a minimum thickness of 5 inches and be provided with control joints spaced at maximum 10-foot intervals. A modulus of subgrade reaction of 125 pounds per cubic foot may be used for design of the public and access roads.

Reinforcement

All concrete flatwork having their largest plan-view panel dimension exceeding 10 feet should be reinforced with a minimum of No. 3 bars spaced 24 inches on centers, both ways. Alternatively, the slab reinforcement may consist of welded wire mesh of the sheet type (not rolled) with 6x6/W1.4xW1.4 designation in accordance with the Wire Reinforcement Institute (WRI). The reinforcement should be properly positioned near the middle of the slabs.

> *The reinforcement recommendations provided herein are intended as guidelines to achieve adequate performance for anticipated soil conditions. The project architect, civil, or structural engineer should make appropriate adjustments in reinforcement type, size and spacing to account for concrete internal (e.g., shrinkage and thermal) and external (e.g., applied loads) forces as deemed necessary.*

Edge Beams

Where the outer edges of concrete flatwork are to be bordered by landscaping, it is recommended that consideration be given to the use of edge beams (thickened edges) to prevent excessive infiltration and accumulation of water under the slabs. Edge beams, if used, should be 6 to 8 inches wide, extend 8 inches below the tops of the finish slab surfaces. Although edge beams are not required, their inclusion in flatwork construction adjacent to landscaped areas is intended to reduce the potential for vertical and horizontal movement and subsequent cracking of the flatwork related to uplift forces that can develop in expansive soils.

Subgrade Preparation

Compaction

To reduce the potential for distress to concrete flatwork, the subgrade soils below concrete flatwork areas should be moisture conditioned to at least optimum moisture content and compacted to a minimum relative compaction of 90 percent to a minimum depth of 12 inches (or deeper, as either prescribed elsewhere in this report or determined in the field). Where concrete public roads, concrete segments of roads, or concrete access driveways are proposed, the upper 12 inches of subgrade soil should be compacted to at least 95 percent relative compaction.

Pre-Moistening

To further reduce the potential for concrete flatwork cracking, subgrade soils should be thoroughly moistened prior to placing concrete. The moisture content of the soils should be at least 1.2 times the optimum moisture content and penetrate to a minimum depth of 12 inches into the subgrade. Flooding or ponding of the subgrade is not recommended as this would require construction of numerous earth berms to contain the water. Moisture conditioning should be achieved with a light spray applied to the subgrade over a period of time until recommended moisture content is achieved prior to pouring concrete. Pre-watering of the soils is intended to promote uniform curing of the concrete, reduce the development of shrinkage cracks, and reduce the potential for differential expansion pressure on freshly poured flatwork. A representative of the project geotechnical consultant should observe and verify the density and moisture content of the soils, and the depth of moisture penetration prior to pouring concrete.

Drainage

Drainage from patios and other flatwork areas should be directed to local area drains or graded earth swales designed to carry runoff water to approved drainage structures. The concrete flatwork should be sloped at a minimum gradient of one percent, or as prescribed by project civil engineer or local codes, away from building foundations, retaining walls, masonry garden walls and slope areas.

Tree Wells

Tree wells are not recommended in concrete flatwork areas since they introduce excessive water into the subgrade soils and allow root invasion, both of which can cause heaving and cracking of the flatwork.

GRADING AND FINAL PLAN REVIEWS

This report has been prepared for the exclusive use of Diversified Pacific Communities to assist the project engineers and architect in the design of the proposed development. It is recommended that Petra be engaged to review the rough grading and any other final-design drawings and specifications prior to construction to ensure that the recommendations contained in this report have been properly interpreted and are incorporated into the project specifications. If Petra is not given the opportunity to review these documents, we take no responsibility for misinterpretation of our recommendations.

We recommend that Petra be retained to provide soil-engineering services during construction of the excavation and foundation phases of the work to ensure compliance with the design, specifications, and recommendations, and to allow design changes in the event that subsurface conditions differ from those anticipated prior to start of construction.

If the project plans change significantly (e.g., major slopes or type of structures), we should review our original design recommendations and their applicability to the revised construction. If conditions are encountered during construction that are different than those indicated in this report, this office should be notified immediately. Design and construction revisions may be needed.

REPORT LIMITATIONS

This report is based on the proposed residential development, our preliminary subsurface exploration, geotechnical laboratory testing, and analysis. The materials encountered on the project site and utilized in our laboratory evaluation are believed representative of the total area; however, soil materials, moisture contents, and oversize rock conditions can vary in characteristics between excavations, both laterally and vertically.

The conclusions and opinions contained in this report are based on the results of the described geotechnical evaluations and represent our professional judgment. This report has been prepared consistent with that level of care being provided by other professionals providing similar services at the same locale and in the same time period. The contents of this report are professional opinions and as such, are not to be considered a guaranty or warranty. This report has not been prepared for use by parties or projects other than those named or described herein. This report may not contain sufficient information for other parties or other purposes. In addition, this report should be reviewed and updated after a period of 1 year or if the site ownership or project concept changes from that described herein.

This opportunity to be of service is sincerely appreciated. If you have any additional questions or concerns, please feel free contact this office.

Respectfully submitted,
PETRA GEOSCIENCES, INC.

8/12/24

Paul D. Theriault
Associate Geologist
CEG 2374

PROFESSIONAL GEOLOGIST
PAUL D. THERIAULT
No. 2374
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

Siamak Jafroudi, PhD
Senior Principal Engineer
GE 2024

REGISTERED PROFESSIONAL ENGINEER
SIAMAK JAFROUDI
No. GE002024
GEOTECHNICAL
STATE OF CALIFORNIA

PDT/SJ/lv

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FIGURES

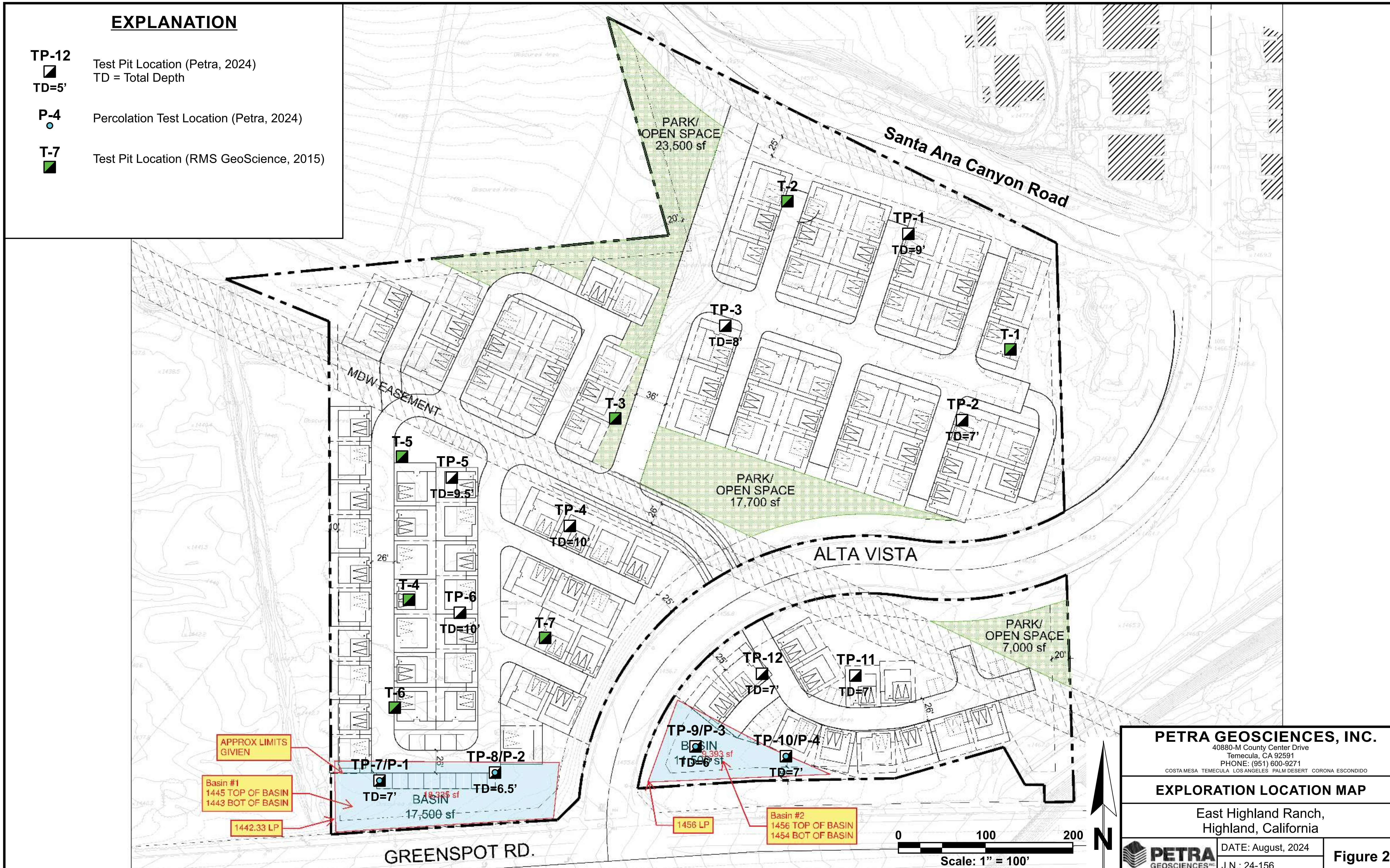
PETRA GEOSCIENCES, INC.
3186 Airway Avenue, Suite K
Costa Mesa, California 92626
PHONE: (714) 549-8921
COSTA MESA TEMECULA LOS ANGELES PALM DESERT CORONA ESCONDIDO

SITE LOCATION MAP

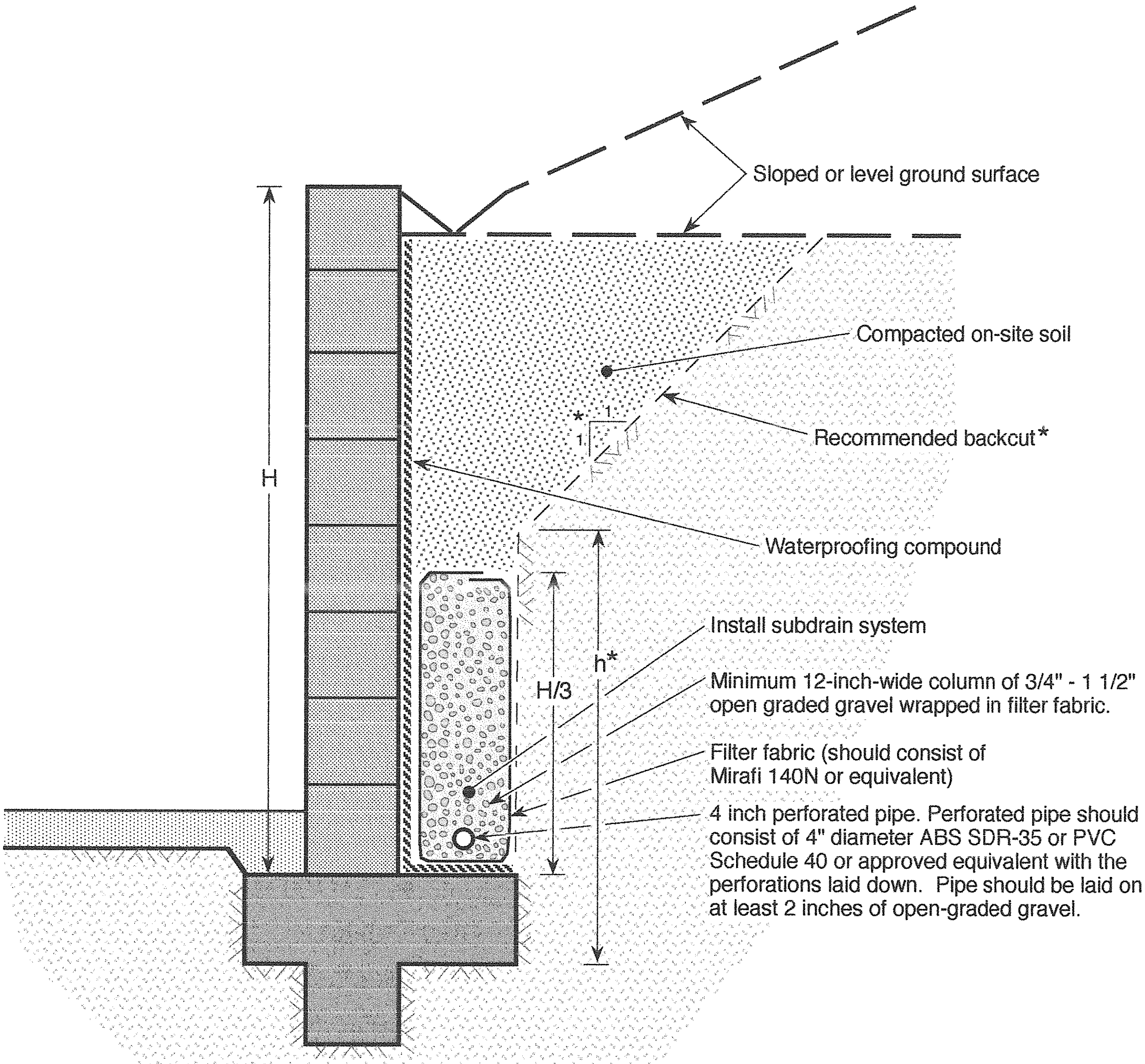
EAST HIGHLAND RANCH
HIGHLAND, CALIFORNIA

DATE: August, 2024
J.N.: 24-156

Figure 1


EXPLANATION
TP-12
TD=5'
Test Pit Location (Petra, 2024)
TD = Total Depth
P-4
Percolation Test Location (Petra, 2024)
T-7
Test Pit Location (RMS GeoScience, 2015)
Santa Ana Canyon Road
PARK/ OPEN SPACE 23,500 sf
PARK/ OPEN SPACE 17,700 sf
PARK/ OPEN SPACE 7,000 sf
MDW EASEMENT
ALTA VISTA
GREENSPOT RD.
T-1
T-2
T-3
T-4
T-5
T-6
T-7
TP-1 TD=9'
TP-2 TD=7'
TP-3 TD=8'
TP-4 TD=10'
TP-5 TD=9.5'
TP-6 TD=10'
TP-7/P-1 TD=7'
TP-8/P-2 TD=6.5'
TP-9/P-3 TD=6'
TP-10/P-4 TD=7'
TP-11 TD=7'
TP-12 TD=7'
BASIN 17,500 sf
BASIN 11,500 sf
APPROX LIMITS GIVIEN
Basin #1
1445 TOP OF BASIN
1443 BOT OF BASIN
1442.33 LP
1456 LP
Basin #2
1456 TOP OF BASIN
1454 BOT OF BASIN
0 100 200
Scale: 1" = 100'
N
PETRA GEOSCIENCES, INC.
40880-M County Center Drive
Temecula, CA 92591
PHONE: (951) 600-9271
COSTA MESA TEMECULA LOS ANGELES PALM DESERT CORONA ESCONDIDO
EXPLORATION LOCATION MAP
East Highland Ranch,
Highland, California
DATE: August, 2024
J.N.: 24-156
Figure 2

NATIVE SOIL BACKFILL



* Vertical height (h) and slope angle of backcut per soils report. Based on geologic conditions, configuration of backcut may require revisions (i.e. reduced vertical height, revised slope angle, etc.)

PETRA	RETAINING WALL BACKFILL AND SUBDRAIN DETAILS	FIGURE RW-1

APPENDIX A

FIELD EXPLORATION LOGS
(PETRA, 2024; RMA, 2015)

Key to Soil and Bedrock Symbols and Terms

PETRA

Unified Soil Classification System

Coarse-grained Soils > 1/2 of materials is larger than #200 sieve	The No. 200 U.S. Standard Sieve is about the smallest particle visible to the naked eye	GRAVELS more than half of coarse fraction is larger than #4 sieve	Clean Gravels (less than 5% fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
				GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
			Gravels with fines	GM	Silty Gravels, poorly-graded gravel-sand-silt mixtures
				GC	Clayey Gravels, poorly-graded gravel-sand-clay mixtures
		SANDS more than half of coarse fraction is smaller than #4 sieve	Clean Sands (less than 5% fines)	SW	Well-graded sands, gravelly sands, little or no fines
				SP	Poorly-graded sands, gravelly sands, little or no fines
			Sands with fines	SM	Silty Sands, poorly-graded sand-gravel-silt mixtures
				SC	Clayey Sands, poorly-graded sand-gravel-clay mixtures
Fine-grained Soils > 1/2 of materials is smaller than #200 sieve		SILTS & CLAYS Liquid Limit Less Than 50		ML	Inorganic silts & very fine sands, silty or clayey fine sands, clayey silts with slight plasticity
				CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
				OL	Organic silts & clays of low plasticity
		SILTS & CLAYS Liquid Limit Greater Than 50		MH	Inorganic silts, micaceous or diatomaceous fine sand or silt
				CH	Inorganic clays of high plasticity, fat clays
				OH	Organic silts and clays of medium-to-high plasticity
Highly Organic Soils				PT	Peat, humus swamp soils with high organic content

Grain Size

Description		Sieve Size	Grain Size	Approximate Size
Boulders		>12"	>12"	Larger than basketball-sized
Cobbles		3 - 12"	3 - 12"	Fist-sized to basketball-sized
Gravel	coarse	3/4 - 3"	3/4 - 3"	Thumb-sized to fist-sized
	fine	#4 - 3/4"	0.19 - 0.75"	Pea-sized to thumb-sized
Sand	coarse	#10 - #4	0.079 - 0.19"	Rock salt-sized to pea-sized
	medium	#40 - #10	0.017 - 0.079"	Sugar-sized to rock salt-sized
	fine	#200 - #40	0.0029 - 0.017"	Flour-sized to sugar-sized to
Fines		Passing #200	<0.0029"	Flour-sized and smaller

Modifiers

Trace	< 1 %
Few	1 - 5%
Some	5 - 12 %
Numerous	12 - 20 %

Laboratory Test Abbreviations

MAX	Maximum Dry Density	MA	Mechanical (Particle Size) Analysis
EXP	Expansion Potential	AT	Atterberg Limits
SO4	Soluble Sulfate Content	#200	#200 Screen Wash
RES	Resistivity	DSU	Direct Shear (Undisturbed Sample)
pH	Acidity	DSR	Direct Shear (Remolded Sample)
CON	Consolidation	HYD	Hydrometer Analysis
SW	Swell	SE	Sand Equivalent
CL	Chloride Content	OC	Organic Content
RV	R-Value	COMP	Mortar Cylinder Compression

Bedrock Hardness

Soft	Can be crushed and granulated by hand; "soil like" and structureless
Moderately Hard	Can be grooved with fingernails; gouged easily with butter knife; crumbles under light hammer blows
Hard	Cannot break by hand; can be grooved with a sharp knife; breaks with a moderate hammer blow
Very Hard	Sharp knife leaves scratch; chips with repeated hammer blows

Sampler and Symbol Descriptions

Approximate Depth of Groundwater Encountered

Approximate Depth of Standing Groundwater

Modified California Split Spoon Sample

No Recovery in Mod. Calif. Split Spoon Sample

Standard Penetration Test

Shelby Tube Sample

Bulk Sample

No Recovery in SPT Sampler

No Recovery in Shelby Tube

Notes:

Blows Per Foot: Number of blows required to advance sampler 1 foot (unless a lesser distance is specified). Samplers in general were driven into the soil or bedrock at the bottom of the hole with a standard (140 lb.) hammer dropping a standard 30 inches unless noted otherwise in Log Notes. Drive samples collected in bucket auger borings may be obtained by dropping non-standard weight from variable heights. When a SPT sampler is used the blow count conforms to ASTM D-1586

TEST PIT LOG

Project: **East Highland Ranch**		Boring No.:	**TP-1**
Location: **Highland**		Elevation:	**1464±**
Job No.: **24-156**	Client: **Diversified Pacific Communities**	Date:	**3/26/24**
Drill Method: **Backhoe**	Driving Weight: **N/A**	Logged By:	**SS**

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**ARTIFICIAL FILL (af)** Silty SAND (SM): Light brown to brown, slightly moist, loose, fine- to coarse-grained, some gravel, 15% cobbles and boulders.							
		ALLUVIUM (Qal) SAND with Silt (SP-SM): Light brown, slightly moist, loose medium dense, fine- to coarse-grained, some gravel, 50% cobbles and boulders.					6.3	93.1	
						■			
							8.1	86.6	
5									
							4.8	104.1	
		25% cobbles and boulders.							
10		Total Depth = 9' No groundwater encountered Slight caving from 6-9' Test Pits backfilled with spoils Moisture and dry density reading taken on site with Nuke Gauge.							
15									
20									
25									
30									
35									

Petra Geosciences, Inc.

TEST PIT LOG

Project:	East Highland Ranch		Boring No.:	TP-2
Location:	Highland		Elevation:	1461±
Job No.:	24-156	Client: Diversified Pacific Communities	Date:	3/26/24
Drill Method:	Backhoe	Driving Weight: N/A	Logged By:	SS

Depth (Feet)	Lithology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**ARTIFICIAL FILL (af)** Silty SAND (SM): Light brown, dry to slightly moist, loose, fine- to coarse-grained, some gravel, 25% cobbles and boulders.				■	2.2	93.1	
		ALLUVIUM (Qal) SAND (SP): Light brown to gray, slightly moist, loose to medium dense, fine- to coarse-grained, some gravel, 35% cobbles and boulders.				■	4.0	94.2	
5							3.6	100.0	
		Total Depth = 7' No groundwater encountered Slight caving from 5-7' Test Pits backfilled with spoils Moisture and dry density reading taken on site with Nuke Gauge.							
10									
15									
20									
25									
30									
35									

Petra Geosciences, Inc.

TEST PIT LOG

Project: **East Highland Ranch**		Boring No.:	**TP-3**
Location: **Highland**		Elevation:	**1453±**
Job No.: **24-156**	Client: **Diversified Pacific Communities**	Date:	**3/26/24**
Drill Method: **Backhoe**	Driving Weight: **N/A**	Logged By:	**SS**

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**ALLUVIUM (Qal)** Silty SAND (SM): Light brown, slightly moist, loose, fine- to medium-grained, some gravel, 35% cobbles and boulders.					5.3	90.8	
		SAND (SP): Light brown to gray, slightly moist, loose, fine- to coarse-grained, some gravel, 35% cobbles and boulders.							
		SAND with Silt (SP-SM): Light brown to brown, slightly moist, loose, fine- to coarse-grained, some gravel, 55% cobbles and boulders.				■	8.6	97.8	
5							4.4	98.3	
		Total Depth = 8' No groundwater encountered Slight caving from 6-8' Test Pits backfilled with spoils Moisture and dry density reading taken on site with Nuke Gauge.							
10									
15									
20									
25									
30									
35									

PLATE A-3

Petra Geosciences, Inc.

TEST PIT LOG

Project: **East Highland Ranch**		Boring No.:	**TP-4**
Location: **Highland**		Elevation:	**1454±**
Job No.: **24-156**	Client: **Diversified Pacific Communities**	Date:	**3/26/24**
Drill Method: **Backhoe**	Driving Weight: **N/A**	Logged By:	**SS**

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**ALLUVIUM (Qal)** Silty SAND (SM): Light brown to brown, dry to slightly moist, loose, fine- to coarse-grained, some gravel, 25% cobbles.							
		SAND with Silt (SP-SM): Light brown, slightly moist, loose to medium dense, fine- to coarse-grained, some gravel, 35% cobbles and boulders.				■	5.7	88.5	
		55% cobbles and boulders.				■	5.8	83.7	MAX, DSR, MA
5							3.6	101.3	
		45% cobbles and boulders.							
10		Total Depth = 10' No groundwater encountered Slight caving from 6-10' Test Pits backfilled with spoils Moisture and dry density reading taken on site with Nuke Gauge.							
15									
20									
25									
30									
35									

PLATE A-4

Petra Geosciences, Inc.

TEST PIT LOG

Project: **East Highland Ranch**		Boring No.:	**TP-5**
Location: **Highland**		Elevation:	**1447±**
Job No.: **24-156**	Client: **Diversified Pacific Communities**	Date:	**3/26/24**
Drill Method: **Backhoe**	Driving Weight: **N/A**	Logged By:	**SS**

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**ALLUVIUM (Qal)** Silty SAND (SM): Light brown, dry, loose, fine- to coarse-grained, some gravel, 35% cobbles.					3.7	114.8	
		SAND (SP): Light brown to brown, slightly moist, loose, some gravel, 50% cobbles and boulders.				■	3.0	114.3	
5							3.6	104.3	
10		Total Depth = 9.5' No groundwater encountered Slight caving from 5-9.5' Test Pits backfilled with spoils Moisture and dry density reading taken on site with Nuke Gauge.							
15									
20									
25									
30									
35									

PLATE A-5

Petra Geosciences, Inc.

TEST PIT LOG

Project:	East Highland Ranch	Boring No.:	TP-6
Location:	Highland	Elevation:	1449±
Job No.: 24-156	Client: Diversified Pacific Communities	Date:	3/26/24
Drill Method: Backhoe	Driving Weight: N/A	Logged By:	SS

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**ALLUVIUM (Qal)** Silty SAND (SM): Light brown to brown, dry to slightly moist, loose, fine- to coarse-grained, some gravel, 25% cobbles.				■			
		SAND with Silt (SP-SM): Light brown, slightly moist, loose, fine- to coarse-grained, some gravel, 35% cobbles and boulders.					4.7	102.6	
		SAND (SP): Light brown, slightly moist, loose, fine- to coarse-grained, some gravel, 45% cobbles and boulders.					5.5	94.6	
5							5.0	105.0	
10		Total Depth = 10' No groundwater encountered Slight caving from 6-10' Test Pits backfilled with spoils Moisture and dry density reading taken on site with Nuke Gauge.							
15									
20									
25									
30									
35									

PLATE A-6

Petra Geosciences, Inc.

TEST PIT LOG

Project:	East Highland Ranch	Boring No.:	TP-7
Location:	Highland	Elevation:	1445±
Job No.: 24-156	Client: Diversified Pacific Communities	Date:	3/26/24
Drill Method: Backhoe	Driving Weight: N/A	Logged By:	SS

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**ALLUVIUM (Qal)** Silty SAND (SM): Light brown, dry, loose, fine- to coarse-grained, some gravel, 25% cobbles.					3.0	105.0	
		SAND with Silt (SP-SM): Light brown to gray, slightly moist, loose, fine- to coarse-grained, some gravel, 45% cobbles and boulders.					3.0	101.3	
5						■	4.0	110.8	
		Total Depth = 7' No groundwater encountered Slight caving from 5-7' Test Pit converted to percolation well P-1 Test Pits backfilled with spoils Moisture and dry density reading taken on site with Nuke Gauge.							
10									
15									
20									
25									
30									
35									

Petra Geosciences, Inc.

TEST PIT LOG

Project: **East Highland Ranch**		Boring No.:	**TP-8**
Location: **Highland**		Elevation:	**1448±**
Job No.: **24-156**	Client: **Diversified Pacific Communities**	Date:	**3/26/24**
Drill Method: **Backhoe**	Driving Weight: **N/A**	Logged By:	**SS**

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**ALLUVIUM (Qal)** Silty SAND (SM): Light brown, dry, loose, fine- to medium-grained, some gravel, few cobbles.							
		SAND (SP): Light brown to gray, slightly moist, loose, fine- to coarse-grained, some gravel, 25% cobbles.				■	3.4	110.3	
		35% cobbles and boulders.					4.2	108.8	
5							4.3	101.9	
		Total Depth = 6.5' No groundwater encountered Slight caving from 5-6.5' Test Pit converted to percolation well P-2 Test Pits backfilled with spoils Moisture and dry density reading taken on site with Nuke Gauge.							
10									
15									
20									
25									
30									
35									

Petra Geosciences, Inc.

TEST PIT LOG

Project:	East Highland Ranch			Boring No.:	TP-9
Location:	Highland			Elevation:	1458±
Job No.:	24-156	Client:	Diversified Pacific Communities	Date:	3/26/24
Drill Method:	Backhoe	Driving Weight:	N/A	Logged By:	SS

Depth (Feet)	Lithology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**ALLUVIUM (Qal)** Silty SAND (SM): Light brown, dry, loose, fine- to coarse-grained, some gravel, 15% cobbles. brown to dark yellow, slightly moist. brown to dark brown, 25% cobbles.					8.6	96.6	
							15.6	88.1	
5						■	33.9	71.9	pH, RES, S04, CL
		Total Depth = 6' No groundwater encountered Slight caving from 5-6' Test Pit converted to percolation well P-3 Test Pits backfilled with spoils Moisture and dry density reading taken on site with Nuke Gauge.							
10									
15									
20									
25									
30									
35									

Petra Geosciences, Inc.

TEST PIT LOG

Project:	East Highland Ranch			Boring No.:	TP-10
Location:	Highland			Elevation:	1461±
Job No.:	24-156	Client:	Diversified Pacific Communities	Date:	3/26/24
Drill Method:	Backhoe	Driving Weight:	N/A	Logged By:	SS

Depth (Feet)	Lithology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**ALLUVIUM (Qal)** Silty SAND (SM): Light brown, dry, loose, fine- to coarse-grained, numerous gravel. Brown to dark brown, slightly moist, 25% cobbles and boulders.							
2–3						■	6.7	104.9	
4							6.2	102.0	
5									
6		SAND (SP): Light brown to brown, slightly moist, loose, fine- to coarse-grained.					13.0	92.2	
7		Total Depth = 7' No groundwater encountered Slight caving from 5-7' Test Pit converted to percolation well P-4 Test Pits backfilled with spoils Moisture and dry density reading taken on site with Nuke Gauge.							
10									
15									
20									
25									
30									
35									

PLATE A-10

Petra Geosciences, Inc.

TEST PIT LOG

Project:	East Highland Ranch	Boring No.:	TP-11
Location:	Highland	Elevation:	1462±
Job No.: 24-156	Client: Diversified Pacific Communities	Date:	3/26/24
Drill Method: Backhoe	Driving Weight: N/A	Logged By:	SS

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**ALLUVIUM (Qal)** Silty SAND (SM): Light brown, dry, loose, fine- to coarse-grained, some gravel, 25% cobbles. Brown to dark brown, slightly moist.					9.0	93.8	
							11.1	89.5	
5		SAND (SP): Light brown, slightly moist, loose, fine- to coarse-grained, some gravel, 25% cobbles, trace boulders.				■	5.4	95.4	
		Total Depth = 7' No groundwater encountered Slight caving from 5-7' Test Pits backfilled with spoils Moisture and dry density reading taken on site with Nuke Gauge.							
10									
15									
20									
25									
30									
35									

Petra Geosciences, Inc.

TEST PIT LOG

Project:	East Highland Ranch			Boring No.:	TP-12
Location:	Highland			Elevation:	1457±
Job No.:	24-156	Client:	Diversified Pacific Communities	Date:	3/26/24
Drill Method:	Backhoe	Driving Weight:	N/A	Logged By:	SS

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**ALLUVIUM (Qal)** Silty SAND (SM): Light brown to brown, dry, loose, fine- to coarse-grained, some gravel, 15% cobbles. Dark brown to brown, slightly moist.							
2							9.2	93.5	
3-4						■			
4							8.2	79.1	
5		SAND (SP): Light brown, slightly moist, loose, fine- to coarse-grained, some gravel, 25% cobbles and boulders.							
6							6.0	103.8	
7		Total Depth = 7' No groundwater encountered Slight caving from 5-7' Test Pits backfilled with spoils Moisture and dry density reading taken on site with Nuke Gauge.							
10									
15									
20									
25									
30									
35									

PLATE A-12

Petra Geosciences, Inc.

Log of Exploratory Trench

Project Name: East Highland Land

Project Number: 15-I27-0

Equipment: Backhoe - Williams Construction

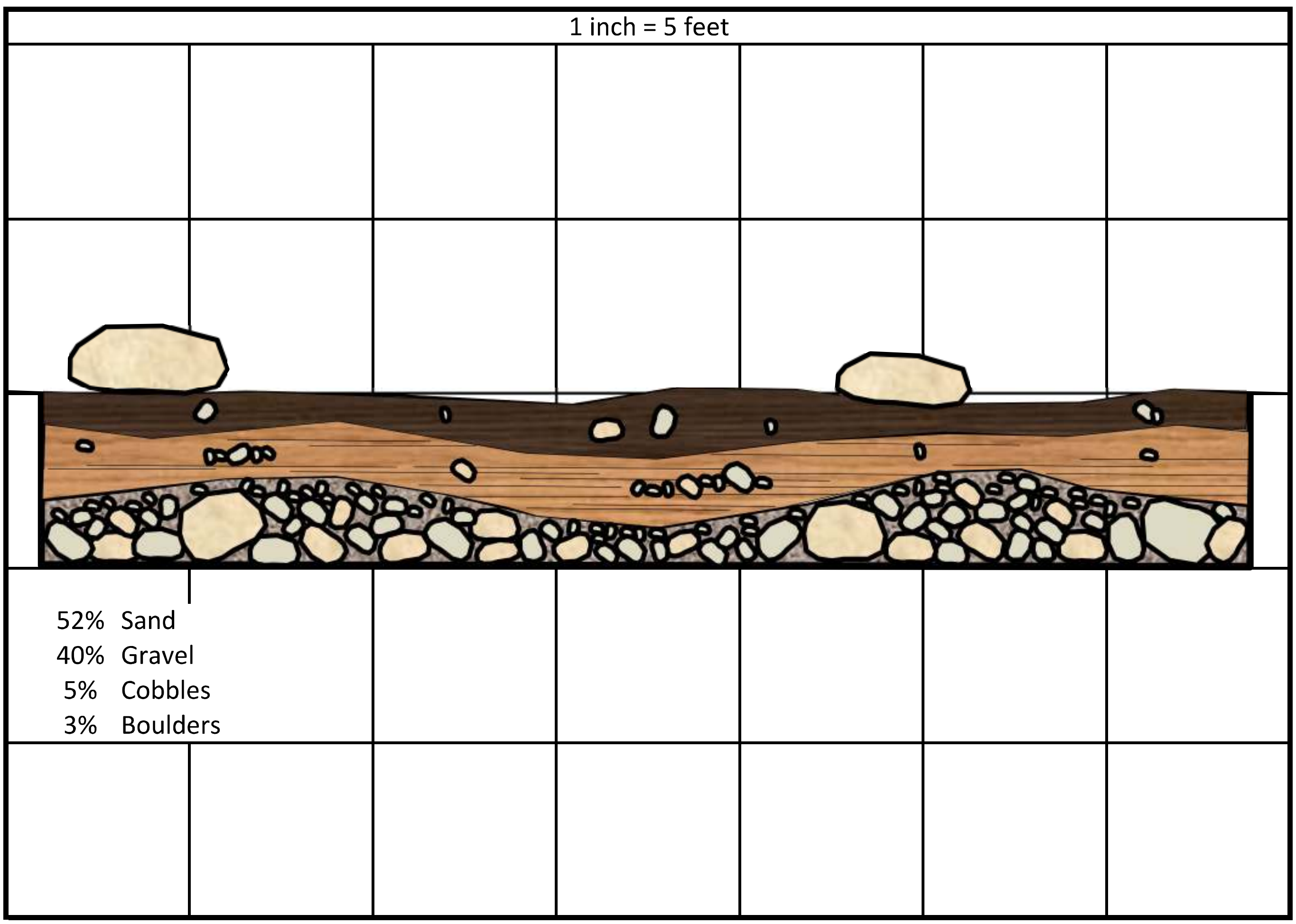
Logged By: ams Elevation: 1466 ft

Trench Number: 1 Date: October 7, 2015

Location: Highland, CA

Notes:

USCS Classification	Density (PCF)	Material Description
-	-	Surface: vegetated with grass and sparse flowers, bushes, and small trees, sporadic boulders ≤ 6' diameter
SM		0-1.5': Dark brown, silty fine to coarse grained sand, slightly moist, roots and rootlets prevalent to approximately 2.5', mottled clay layers 0.5-6 cm thick, subangular to rounded coarse gravel and small cobbles, porous, wavy gradational contact
SW		1.5'-3.5': Light yellow brown, fine to coarse grained laminated to massively bedded sand, dry, sporadic subangular to rounded gravel with lenses of gravel and small cobbles, laminated silt-rich beds gray in color approximately 4-6 cm apart and less than 0.5 cm thick, wavy contact
GW		3.5-5': Light yellow brown, gravel, clasts, and boulders sourced primarily from diorite, granite, and other igneous rocks, dry, normally graded, clast supported with a medium to coarse sand martix



Log of Exploratory Trench

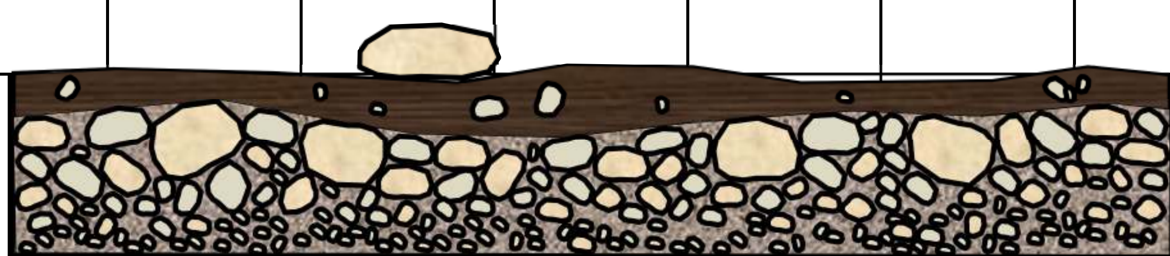
RMA GeoScience

Project Name: East Highland Land
Project Number: 15-I27-0
Equipment: Backhoe - Williams Construction
Logged By: ams Elevation: 1466 ft

Trench Number: 2 Date: October 7, 2015
Location: Highland, CA
Notes:

USCS Classification	Density (PCF)	Material Description
-	-	Surface: vegetated with grass and sparse flowers, bushes, and small trees, sporadic boulders ≤ 6' diameter
SM		0-1.5': Dark brown, silty fine to coarse grained sand, slightly moist, roots and rootlets prevalent, mottled clay layers 0.5-6 cm thick, subangular to rounded coarse gravel and small cobbles, porous, wavy gradational contact
GW		1.5-5': Light yellow brown, gravel, clasts, and boulders sourced primarily from diorite, granite, and other igneous rocks, dry, reverse graded, clast supported with a medium to coarse sand martix

1 inch = 5 feet



45% Sand
40% Gravel
10% Cobbles
5% Boulders

Log of Exploratory Trench

RMA GeoScience

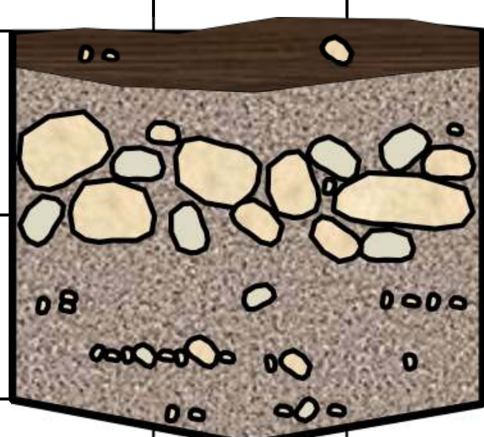
Project Name: East Highland Land
Project Number: 15-I27-0
Equipment: Backhoe - Williams Construction
Logged By: ams Elevation: 1466 ft

Trench Number: 3 Date: October 7, 2015
Location: Highland, CA
Notes:

USCS Classification	Density (PCF)	Material Description
-	-	Surface: vegetated with grass, shrubs, and small trees, sporadic boulders ≤ 4' diameter
SM		0-1': Dark brown, silty fine to coarse grained sand, slightly moist, roots and rootlets to approximately 2 feet prevalent, subangular to rounded coarse gravel and small cobbles, porous, wavy gradational contact
SW		1'-2': White to tan medium to coarse grained clean sand, slightly moist, sproadic roots
GW		2-6': Tan brown sub angular to rounded gravel, cobbles, and boulders with medium to coarse grained sand matrix, dry
SW		6'-8': Yellow tan medium to coarse grained clean sand, dry, sporadic cobbles and gravel in lenses

1 inch = 5 feet

49% Sand
35% Gravel
10% Cobbles
6% Boulders



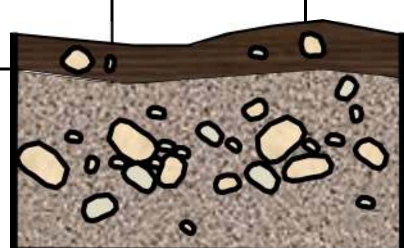
Subject to caving

Log of Exploratory Trench

Project Name: East Highland Land
Trench Number: 4
Date: October 7, 2015
Project Number: 15-I27-0
Location: Highland, CA
Equipment: Backhoe - Williams Construction
Notes:
Logged By: ams
Elevation: 1466 ft

USCS Classification	Density (PCF)	Material Description
-	-	Surface: vegetated with grasses, sporadic boulders ≤ 4' diameter
SM		0-1.5': Dark brown, silty fine to coarse grained sand, slightly moist, roots and rootlets prevalent, subangular to rounded coarse gravel and small cobbles, porous, wavy gradational contact
GW		1.5-6': Light yellow brown fine to coarse sand, gravel, clasts, and boulders sourced primarily from diorite, granite, and other igneous rocks, dry, matrix supported, with lenses of thicker clast supported regions

1 inch = 5 feet



86% Sand
10% Gravel
3% Cobbles
1% Boulders

Subject to caving

Log of Exploratory Trench

RMA GeoScience

Project Name: East Highland Land
Trench Number: 5 Date: October 7, 2015
Project Number: 15-I27-0
Location: Highland, CA
Equipment: Backhoe - Williams Construction
Notes:
Logged By: ams Elevation: 1466 ft

USCS Classification	Density (PCF)	Material Description
-	-	Surface: vegetated with shrubs and small trees, sporadic boulders ≤ 4' diameter
SM		0-1.5': Dark brown, silty fine to coarse grained sand, slightly moist, roots and rootlets prevalent, subangular to rounded coarse gravel and small cobbles, porous, wavy gradational contact
SW		1.5-5': Light yellow brown fine to coarse sand, gravel, clasts, and a few small boulders ,matrix supported, with lenses of thicker clast supported regions

1 inch = 5 feet

RMA GeoScience

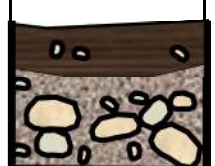
Log of Exploratory Trench

Project Name: East Highland Land
Project Number: 15-I27-0
Equipment: Backhoe - Williams Construction
Logged By: ams Elevation: 1466 ft

Trench Number: 6 Date: October 7, 2015
Location: Highland, CA
Notes:

USCS Classification	Density (PCF)	Material Description
-	-	Surface: vegetated with shrubs and small trees, sporadic boulders ≤ 4' diameter
SM		0-2': Dark brown, silty fine to coarse grained sand, slightly moist, roots and rootlets prevalent, subangular to rounded coarse gravel and small cobbles, porous, wavy gradational contact
SW		2-4': Tan to light brown fine to coarse sand, gravel, clasts, and a few small boulders, matrix supported

1 inch = 5 feet



Log of Exploratory Trench

RMA GeoScience

Project Name: East Highland Land
Trench Number: 7
Date: October 7, 2015
Project Number: 15-I27-0
Location: Highland, CA
Equipment: Backhoe - Williams Construction
Notes:
Logged By: ams
Elevation: 1466 ft

USCS Classification	Density (PCF)	Material Description
-	-	Surface: vegetated with shrubs and small trees, sporadic boulders ≤ 4' diameter
SM		0-1': Dark brown, silty fine to coarse grained sand, slightly moist, roots and rootlets prevalent, subangular to rounded coarse gravel and small cobbles, porous, wavy gradational contact
SW		1-4': Light yellow brown fine to coarse sand, gravel, clasts, and a few small boulders matrix supported

1 inch = 5 feet

Subject to caving

APPENDIX B

LABORATORY TEST PROCEDURES

LABORATORY DATA SUMMARY (PETRA, 2024; RMA, 2015)

LABORATORY TEST PROCEDURES

Soil Classification

Soils encountered within the exploration borings were initially classified in the field in general accordance with the visual-manual procedures of the Unified Soil Classification System (ASTM D 2488). The samples were re-examined in the laboratory and the classifications reviewed and then revised where appropriate.

Laboratory Maximum Dry Density and Optimum Moisture Content

The maximum dry unit weight and optimum moisture content of various on-site soil types were determined for selected bulk samples in accordance with current version of Method A of ASTM D 1557. The results of these tests are presented on Plate B-1.

Expansion Index

Expansion index tests were performed on selected samples of soil in accordance with ASTM D 4829. The expansion potential classification was determined from 2016 CBC Section 1802.3.2 on the basis of the expansion index value. The test results and expansion potential are presented on Plate B-1.

Soil Corrosivity

Chemical analyses were performed on a selected sample of soil to determine concentrations of soluble sulfate and chloride, as well as pH and resistivity. These tests were performed in accordance with California Test Method Nos. 417 (sulfate), 422 (chloride) and 643 (pH and resistivity). Test results are included on Plate B-1.

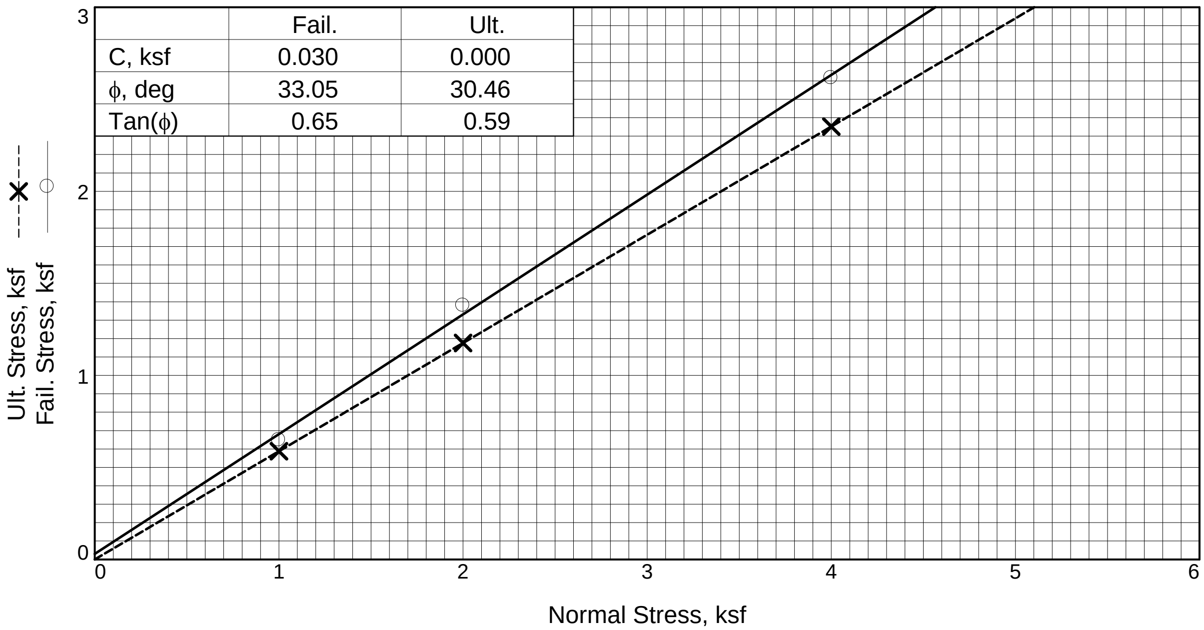
Direct Shear-Remolded

The Coulomb shear strength parameters, angle of internal friction and cohesion, were determined for undisturbed and disturbed (bulk) samples remolded to approximately 90 percent of maximum dry density. These tests were performed in general accordance with ASTM D 3080. Three specimens were prepared for each test. The test specimens were artificially saturated, and then sheared under varied normal loads at a maximum constant rate of strain of 0.05 inches per minute. Results are graphically depicted on Plate B-2.

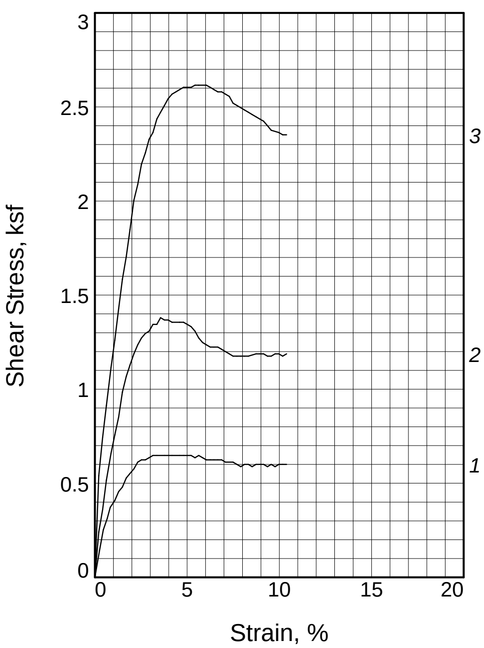
LABORATORY DATA SUMMARY														
Test Pit Number	Sample Depth (ft)	Soil Description	Compaction[1]		Expansion[2]		Atterberg Limits[3]			Soluble Sulfate Content[4] (%)	Chloride Content[5] (ppm)	pH[6]	Minimum Resistivity[6] (Ohm-cm)
			Max. Dry Density (pcf)	Optimum Moisture (%)	Index	Potential	LL	PL	PI				
3	3-5	Sand with Gravel/Cobbles	120.5	9.5	-	-	-	-	-	-	-	-	-
6	1	Sand with Gravel/Cobbles	-	-	0	Non Expansive	-	-	-	-	-	-	-
9	4	Sand with Gravel/Cobble some Silt	-	-	-	-	-	-	-	0.0030	315	6.4	3,200

Test Procedures:

[1] Per ASTM Test Method ASTM D 1557
[2] Per ASTM Test Method ASTM D 4829
[3] Per ASTM Test Method ASTM D 4318
[4] Per California Test Method CTM 417
[5] Per California Test Method CTM 422
[6] Per California Test Method CTM 643



	Fail.	Ult.
C, ksf	0.030	0.000
ϕ, deg	33.05	30.46
Tan(ϕ)	0.65	0.59



Sample No.		1	2	3
Initial	Water Content, %	10.5	10.5	10.5
	Dry Density, pcf	103.6	103.9	104.3
	Saturation, %	46.6	47.0	47.5
	Void Ratio	0.5969	0.5921	0.5859
	Diameter, in.	2.416	2.416	2.416
	Height, in.	1.017	1.014	1.010
At Test	Water Content, %	20.8	20.6	19.6
	Dry Density, pcf	104.8	106.4	108.0
	Saturation, %	95.4	98.6	97.8
	Void Ratio	0.5790	0.5545	0.5315
	Diameter, in.	2.416	2.416	2.416
	Height, in.	1.006	0.990	0.975
Normal Stress, ksf		1.000	2.000	4.000
Fail. Stress, ksf		0.648	1.380	2.616
Strain, %		4.0	3.6	6.0
Ult. Stress, ksf		0.588	1.176	2.352
Strain, %		9.8	7.5	10.4
Strain rate, in./min.		0.040	0.040	0.040

Sample Type: Remolded
Description: Brown Fine to Coarse Sand with Gravel

Specific Gravity= 2.65
Remarks:

Figure ________

Client: Diversified Pacific

Project: East Highland Ranch

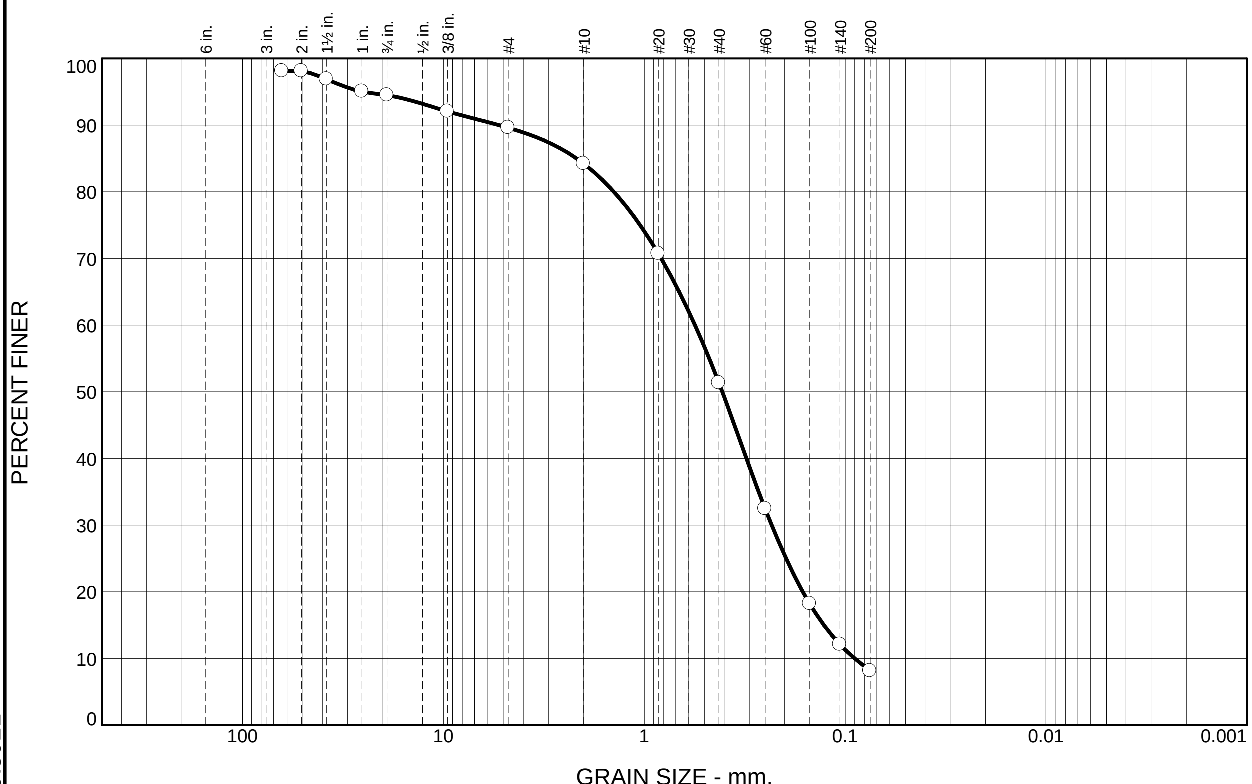
Source of Sample: 24L052 **Depth:** 3-5
Sample Number: TP-4
Proj. No.: 24-156 **Date Sampled:** 7/17/2024

PETRA GEOSCIENCES INC.

Laboratory:
1251 West Pomona Road, Unit #103, Corona, Ca 92882 Phone #. 714.549.8921

Tested By: DI

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		4.9	5.4	32.9	43.2	8.1	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
2.5	98.1		
2	98.1		
1.5	96.9		
1	95.0		
.75	94.5		
.375	92.1		
#4	89.6		
#10	84.2		
#20	70.7		
#40	51.3		
#60	32.4		
#100	18.2		
#140	12.1		
#200	8.1		

* (no specification provided)

Soil Description

Brown Fine to Coarse Sand with Gravel

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 5.3040 D_{85}= 2.1732 D_{60}= 0.5589
D_{50}= 0.4089 D_{30}= 0.2321 D_{15}= 0.1276
D_{10}= 0.0896 C_u= 6.24 C_c= 1.08

Classification

USCS= AASHTO=

Remarks

Source of Sample: 24L052 **Depth:** 3-5
Sample Number: TP-4

Date: 7/17/2024

PETRA GEOSCIENCES INC.

Client: Diversified Pacific
Project: East Highland Ranch
Project No: 24-156 **Figure**

Laboratory:
1251 West Pomona Road, Unit #103, Corona, Ca 92882 Phone #. 714.549.8921

Tested By: DI

APPENDIX B

B-1.00 LABORATORY TESTS

B-1.01 Maximum Density

Maximum density - optimum moisture relationships for the major soil types encountered during the field exploration were performed in the laboratory using the standard procedures of ASTM D1557.

B-1.02 Test Results

Test results for all laboratory tests performed on the subject project are presented in this appendix. For a sample-by-sample description, see the Trench Logs presented in Appendix A.

MAXIMUM DENSITY - OPTIMUM MOISTURE
(Test Method: ASTM D1557)

Sample Number	Optimum Moisture (Percent)	Maximum Density (lbs/ft^3)
T-2 at 0-2 ft	9.8	123.7
T-3 at 1-3 ft	___	___

APPENDIX C

PERCOLATION TEST PROCEDURES / RESULTS

Preliminary Percolation Tests Results

Percolation testing was performed to evaluate infiltration rates of the site soils, consisting of alluvial deposits, to aid in the design of proposed stormwater basins.

Test Method

Methodology included drilling four borings to depths between 7 and 8 feet below the existing ground surface, to the bottom elevation of the proposed basins. We subsequently performed falling head percolation tests in each of the four borings. The depths and locations of the percolation tests were provided by Kimley Horn. The locations of the percolation boreholes are shown in Figure 2.

Percolation tests to evaluate site infiltration rates were performed in conformance with Design Handbook for Low Impact Development, Best Management Practices, by Riverside County Flood Control and Water Conservation District, dated September 2011 (Handbook). Log and field-classify soil materials encountered in each boring in accordance with the visual-manual procedures outlined in the Unified Soil Classification System and the American Society for Testing and Materials (ASTM) Procedure D 2488-90. All field activities were performed by or under the direct observation of a State of California Certified Engineering Geologist.

Test Description and Results

The falling head percolation testing method was used in accordance with the above-referenced Handbook. The borings for the percolation tests were advanced using an 8-inch diameter hollow-stem auger to depths of approximately 7 to 8 feet below the existing ground surface. Percolation testing was performed in the bottom one foot of the boreholes, within the alluvial deposits. The locations of the percolation test borings are shown on Figure 2. Logs of percolation test borings are provided in Appendix A. A grain size analysis was performed on a representative soil sample. Laboratory results are presented in Appendix B.

Following a presoaking period, field testing was conducted in a perforated pipe lowered into the borehole, with ¾-inch gravel surrounding the pipe. Tests were conducted at 10-minute intervals for a period of approximately one hour. The falling-head percolation test data were utilized in determining the test infiltration rate, I_t, expressed in units of inches/hour, utilizing the Porchet Method (RCFCWCD, 2011). The infiltration rate, I_t, was calculated by determining the volumetric water flow rate through the wetted borehole surface area. The un-factored test results are summarized in the following table, Table 1. It should be noted that infiltration rates were higher than measurable in accordance the Handbook, as such, the time to record a drop of 12 inches was used in the time interval column on the percolation test sheets.

TABLE 1

Un-Factored Infiltration Test Results

Test No.	**Borehole Total Depth (feet)**	**Approx. Test Zone (feet below existing grade)**	**Geologic Unit / Soil Description**	**Infiltration Test Rate, I_t (in/hr)**
P-1	8	7-8	Qal Poorly Graded Silty SAND with Gravel (SP-SM)	29.38
P-2	7.5	6.5-7.5	Qal Poorly Graded SAND (SP)	29.48
P-3	7	6-7	Qal Silty SAND (SM)	29.48
P-4	8	7-8	Qal Poorly Graded SAND (SP)	29.48

The test data indicates the alluvial deposits at the depths evaluated are considered permeable. It is our professional opinion that the infiltration rates measured 7 to 8 feet below ground surface, as well as the material descriptions, are indicative of sufficient permeability to be suitable for the intended infiltration purposes.

Discussion

Suitability Assessment

In view of the test data, certain jurisdictions consider such factors as infiltration assessment method, soil texture, site soils variability, and depth to groundwater/impervious layer to assign a Suitability Assessment Safety Factor that should be applied to the infiltration rates.

To perform such an evaluation, we have adopted a procedure provided by Santa Ana Regional Water Quality Control Board (SARWQCB) in their Technical Guidance Document (TGD) for the Preparation of Conceptual/Preliminary and/or Project Water Quality Management Plans (WQMPs), with Appendices, For Santa Ana Regional Board consideration, dated December 20, 2013 (SARWQCB, 2013). Based on Appendix D of this document, using Table VII.3: Suitability Assessment Related Considerations for Infiltration Facility Safety Factors, and Worksheet H: Factor of Safety and Design Infiltration Rate and Worksheet, of the Orange County BMP Design Manual, the following is presented.

TABLE 2

Site Suitability Reduction Factor (Category A) for Infiltration Rate

Considerations		Concern		Reduction Factor
Description	**Weight**	**Level**	**Safety Factor**	**Weight x Safety Factor**
Soil Assessment Method	0.25	Low	1.0	0.25
Predominant Soil Texture	0.25	Low	1.0	0.25
Site Soil Variability	0.50	Medium	1.0	0.50
Depth to Groundwater/Impervious Layer	0.25	Low	1.0	0.25
Reduction Factor (sum of individual Reduction Factors)				**1.25**

Based on the information provided in Table 2, a Reduction Factor of 1.25 should be applied to the values of Infiltration Rate, I_t, provided in Table 1, above, for Site Suitability considerations.

Construction Procedure

The infiltration rates provided herein are considered representative of the native soils in the vicinity of the percolation test locations. Care should be taken to minimize disturbance of the exposed bottom surface of the basins as fill placement or any compaction effort applied to the area will have a detrimental effect on the anticipated infiltration rate of the proposed infiltration areas.

Environmental Impact

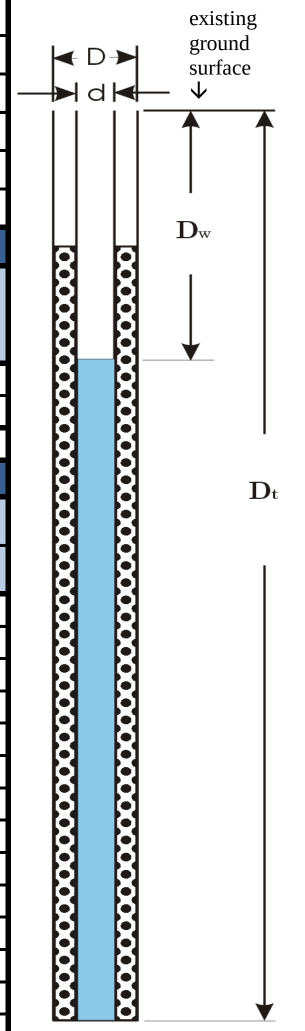
It should be noted that clean, potable water was used for the test. Surface runoff usually carries with it debris and fine particles that are typically expected to reduce the calculated infiltration rate.

Factor of Safety

The values of infiltration rate provided in Table 1 are raw test values. As discussed above, these values should be corrected for site suitability considerations by applying a Reduction factor as provided in Table 2. Further, the project civil engineer needs to consider a Design Safety Factor, which incorporates such items as tributary area size, level of pretreatment/expected sediment load, redundancy/contingency plan, and compaction during construction, in combination with the Suitability Assessment Safety/Reduction Factor for the design of the system.

Boring/Test Number: P-1

Total Depth of Boring, D_T (ft):	8	**Test Date:**	3/27/2024
Diameter of Hole, D (in):	6	**Tested By:**	SS
Diameter of Casing, d (in):	2	**USCS Soil Type:**	SP-SM
Depth of Slotted Casing (ft):	3 to 8	**Depth to Groundwater (ft):**	
Porosity of Annulus Material, *n* :	0.44	**Ground Elevation (msl ft):**	1445
Depth from Existing Ground Surface to Bottom of Prop. Infiltration System (ft):			



SANDY SOIL CRITERIA TEST

Trial No.	Time Interval Δt (min.)	Depth to Water, D_w		Change in Water Level ΔD (in.)	Change in Height of Water Greater Than or Equal to 6"? (Yes/No)*
		Initial, D_o (ft.)	Final, D_f (ft.)		
1	25	6.90	8.04	13.68	yes
2	25	6.90	8.04	13.68	yes

Standard Time Interval Between Readings (min.), [* if yes = 10, if no = 30]: 10

PERCOLATION TEST

Trial No.	Time Interval Δt (min.)	Depth to Water, D_w		Change in Water Level ΔH (in.)	Percolation Rate	
		Initial, D_o (ft.)	Final, D_f (ft.)		(min/in.)	(gal/day/ft^2)
1	2.07	6.90	7.90	12.00	0.17	450.60
2	2.53	6.90	7.90	12.00	0.21	368.67
3	2.67	6.90	7.90	12.00	0.22	349.34
4	2.83	6.90	7.90	12.00	0.24	329.59
5	2.83	6.90	7.90	12.00	0.24	329.59
6	2.83	6.90	7.90	12.00	0.24	329.59

TEST RESULTS**

Inflitration Rate [Porchet Method]# (inches/hour)	Percolation Rate	
	(min/in.)	(gal/day/ft^2)
29.38	**0.24**	**329.59**

**Raw Results. Does Not Include a Factor of Safety

FACTOR OF SAFETY

Testing Option	Testing Requirements	Factor of Safety per Reference
Option 2	**4 tests minimum with at least two borings per basin**	**3**

Where Infiltration Rate, It = ΔH (60r) / Δt (r + 2Havg)

$r = D / 2$

$Ho = D_T - Do$

$H_f = D_T - D_f$

$\Delta H = \Delta D = H_o - H_f$

$H_{avg} = (H_o + H_f) / 2$

Reference:
RCFCWCD, Design Handbook for LID, dated September, 2011

PETRA GEOSCIENCES, INC.
3186 Airway Avenue, Suite K
Costa Mesa, California 92626
PHONE: (714) 549-8921
COSTA MESA TEMECULA LOS ANGELES PALM DESERT CORONA ESCONDIDO

PERCOLATION TEST SUMMARY

Highland Ranch
Highland, CA

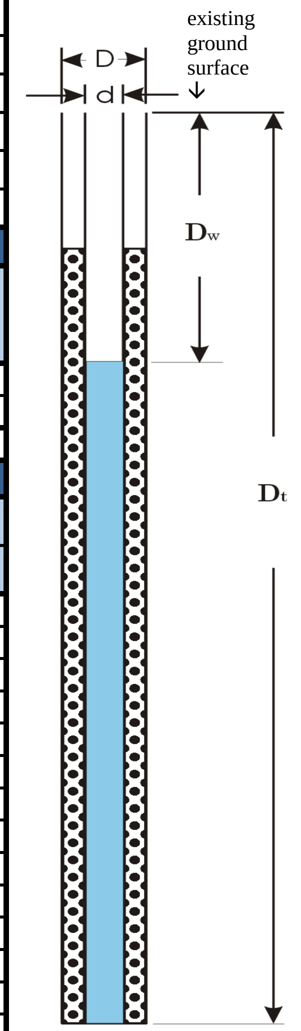
PETRA GEOSCIENCES INC.

DATE: August, 2024
J.N.: 24-156

Appendix C

Boring/Test Number: P-2

Total Depth of Boring, D_T (ft):	7.5	**Test Date:**	3/27/2024
Diameter of Hole, D (in):	6	**Tested By:**	SS
Diameter of Casing, d (in):	2	**USCS Soil Type:**	SP
Depth of Slotted Casing (ft):	2.5 to 7.5	**Depth to Groundwater (ft):**	
Porosity of Annulus Material, *n* :	0.44	**Ground Elevation (msl ft):**	1448
Depth from Existing Ground Surface to Bottom of Prop. Infiltration System (ft):			



SANDY SOIL CRITERIA TEST

Trial No.	Time Interval Δt (min.)	Depth to Water, D_w		Change in Water Level ΔD (in.)	Change in Height of Water Greater Than or Equal to 6"? (Yes/No)*
		Initial, D_o (ft.)	Final, D_f (ft.)		
1	25	6.40	7.45	12.6	yes
2	25	6.40	7.48	12.96	yes

Standard Time Interval Between Readings (min.), [* if yes = 10, if no = 30]: 10

PERCOLATION TEST

Trial No.	Time Interval Δt (min.)	Depth to Water, D_w		Change in Water Level ΔH (in.)	Percolation Rate	
		Initial, D_o (ft.)	Final, D_f (ft.)		(min/in.)	(gal/day/ft^2)
1	3.33	6.40	7.40	12.00	0.28	280.10
2	3.75	6.40	7.40	12.00	0.31	248.73
3	3.93	6.40	7.40	12.00	0.33	237.34
4	3.98	6.40	7.40	12.00	0.33	234.36
5	4.20	6.40	7.40	12.00	0.35	222.08
6	4.13	6.40	7.40	12.00	0.34	225.85
7	4.25	6.40	7.40	12.00	0.35	219.47
8	4.23	6.40	7.40	12.00	0.35	220.51
9	4.25	6.40	7.40	12.00	0.35	219.47
10	4.25	6.40	7.40	12.00	0.35	219.47

TEST RESULTS**

Infiltration Rate [Porchet Method]# (inches/hour)	Percolation Rate	
	(min/in.)	(gal/day/ft^2)
20.13	**0.34**	**225.85**

**Raw Results. Does Not Include a Factor of Safety

FACTOR OF SAFETY

Testing Option	Testing Requirements	Factor of Safety per Reference
Option 2	**4 tests minimum with at least two borings per basin**	**3**

Where Infiltration Rate, $I_t = \Delta H (60r) / \Delta t (r + 2H_{avg})$

$r = D / 2$

$H_o = D_T - D_o$

$H_f = D_T - D_f$

$\Delta H = \Delta D = H_o - H_f$

$H_{avg} = (H_o + H_f) / 2$

Reference:
RCFCWCD, Design Handbook for LID, dated September, 2011

PETRA GEOSCIENCES, INC.
3186 Airway Avenue, Suite K
Costa Mesa, California 92626
PHONE: (714) 549-8921
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PERCOLATION TEST SUMMARY

Highland Ranch
Highland, CA

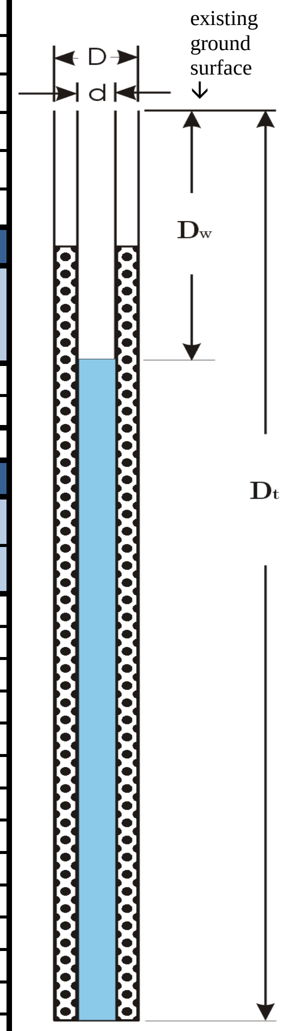
PETRA GEOSCIENCES INC.

DATE: August, 2024
J.N.: 24-156

Appendix C

Boring/Test Number: P-3

Total Depth of Boring, D_T (ft):	7	**Test Date:**	3/27/2024
Diameter of Hole, D (in):	6	**Tested By:**	SS
Diameter of Casing, d (in):	2	**USCS Soil Type:**	SM
Depth of Slotted Casing (ft):	2 to 7	**Depth to Groundwater (ft):**	
Porosity of Annulus Material, *n* :	0.44	**Ground Elevation (msl ft):**	1458
Depth from Existing Ground Surface to Bottom of Prop. Infiltration System (ft):			



SANDY SOIL CRITERIA TEST

Trial No.	Time Interval Δt (min.)	Depth to Water, D_w		Change in Water Level ΔD (in.)	Change in Height of Water Greater Than or Equal to 6"? (Yes/No)*
		Initial, D_o (ft.)	Final, D_f (ft.)		
1	25	5.90	7.18	15.36	yes
2	25	5.90	7.19	15.48	yes

Standard Time Interval Between Readings (min.), [* if yes = 10, if no = 30]: 10

PERCOLATION TEST

Trial No.	Time Interval Δt (min.)	Depth to Water, D_w		Change in Water Level ΔH (in.)	Percolation Rate	
		Initial, D_o (ft.)	Final, D_f (ft.)		(min/in.)	(gal/day/ft^2)
1	2.52	5.90	6.90	12.00	0.21	370.14
2	2.73	5.90	6.90	12.00	0.23	341.66
3	2.82	5.90	6.90	12.00	0.24	330.76
4	2.80	5.90	6.90	12.00	0.23	333.12
5	2.80	5.90	6.90	12.00	0.23	333.12
6	2.82	5.90	6.90	12.00	0.24	330.76

TEST RESULTS**

Infiltration Rate [Porchet Method][#] (inches/hour)	Percolation Rate (min/in.)	Percolation Rate (gal/day/ft^2)
29.48	**0.24**	**330.76**

**Raw Results. Does Not Include a Factor of Safety

FACTOR OF SAFETY

Testing Option	Testing Requirements	Factor of Safety per Reference
Option 2	**4 tests minimum with at least two borings per basin**	**3**

[#] Where Infiltration Rate, It = ΔH (60r) / Δt (r + 2Havg)

$r = D / 2$

$H_o = D_T - D_o$

$H_f = D_T - D_f$

$\Delta H = \Delta D = H_o - H_f$

$H_{avg} = (H_o + H_f) / 2$

Reference:
RCFCWCD, Design Handbook for LID, dated September, 2011

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3186 Airway Avenue, Suite K
Costa Mesa, California 92626
PHONE: (714) 549-8921
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PERCOLATION TEST SUMMARY

Highland Ranch
Highland, CA

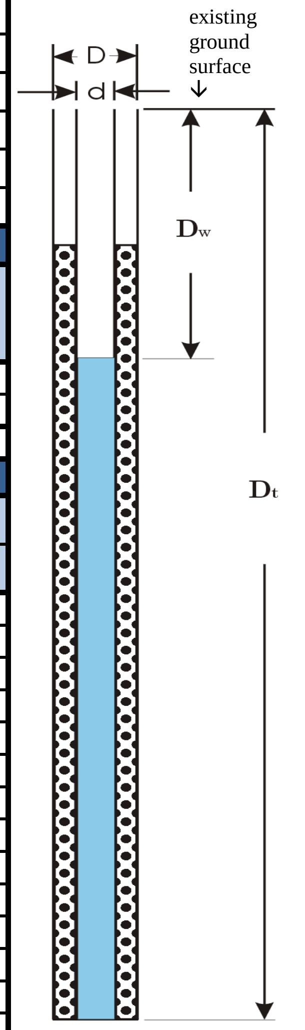
PETRA GEOSCIENCES INC.

DATE: August, 2024
J.N.: 24-156

Appendix C

Boring/Test Number: P-4

Total Depth of Boring, D_T (ft):	8	**Test Date:**	3/27/2024
Diameter of Hole, D (in):	6	**Tested By:**	SS
Diameter of Casing, d (in):	2	**USCS Soil Type:**	SP
Depth of Slotted Casing (ft):	3 to 8	**Depth to Groundwater (ft):**	
Porosity of Annulus Material, *n* :	0.44	**Ground Elevation (msl ft):**	1461
Depth from Existing Ground Surface to Bottom of Prop. Infiltration System (ft):			



SANDY SOIL CRITERIA TEST

Trial No.	Time Interval Δt (min.)	Depth to Water, D_w		Change in Water Level ΔD (in.)	Change in Height of Water Greater Than or Equal to 6"? (Yes/No)*
		Initial, D_o (ft.)	Final, D_f (ft.)		
1	25	6.90	7.98	12.96	yes
2	25	6.90	7.98	12.96	yes

Standard Time Interval Between Readings (min.), [* if yes = 10, if no = 30]: 10

PERCOLATION TEST

Trial No.	Time Interval Δt (min.)	Depth to Water, D_w		Change in Water Level ΔH (in.)	Percolation Rate	
		Initial, D_o (ft.)	Final, D_f (ft.)		(min/in.)	(gal/day/ft^2)
1	2.52	6.90	7.90	12.00	0.21	370.14
2	2.73	6.90	7.90	12.00	0.23	341.66
3	2.82	6.90	7.90	12.00	0.24	330.76
4	2.80	6.90	7.90	12.00	0.23	333.12
5	2.80	6.90	7.90	12.00	0.23	333.12
6	2.82	6.90	7.90	12.00	0.24	330.76

TEST RESULTS**

Infiltration Rate [Porchet Method]# (inches/hour)	Percolation Rate	
	(min/in.)	(gal/day/ft^2)
29.48	**0.24**	**330.76**

**Raw Results. Does Not Include a Factor of Safety

FACTOR OF SAFETY

Testing Option	Testing Requirements	Factor of Safety per Reference
Option 2	**4 tests minimum with at least two borings per basin**	**3**

Where Infiltration Rate, $I_t = \Delta H (60r) / \Delta t (r + 2H_{avg})$

$r = D / 2$

$H_o = D_T - D_o$

$H_f = D_T - D_f$

$\Delta H = \Delta D = H_o - H_f$

$H_{avg} = (H_o + H_f) / 2$

Reference:
RCFCWCD, Design Handbook for LID, dated September, 2011

PETRA GEOSCIENCES, INC.
3186 Airway Avenue, Suite K
Costa Mesa, California 92626
PHONE: (714) 549-8921
COSTA MESA TEMECULA LOS ANGELES PALM DESERT CORONA ESCONDIDO

PERCOLATION TEST SUMMARY

Highland Ranch
Highland, CA

PETRA GEOSCIENCES INC.

DATE: August, 2024 | J.N.: 24-156

Appendix C

APPENDIX D

STANDARD GRADING SPECIFICATIONS

STANDARD GRADING SPECIFICATIONS

These specifications present the usual and minimum requirements for projects on which Petra Geosciences, Inc. (Petra) is the geotechnical consultant. No deviation from these specifications will be allowed, except where specifically superseded in the preliminary geology and soils report, or in other written communication signed by the Soils Engineer and Engineering Geologist of record (Geotechnical Consultant).

I. GENERAL

A. The Geotechnical Consultant is the Owner's or Builder's representative on the project. For the purpose of these specifications, participation by the Geotechnical Consultant includes that observation performed by any person or persons employed by, and responsible to, the licensed Soils Engineer and Engineering Geologist signing the soils report.

B. The contractor should prepare and submit to the Owner and Geotechnical Consultant a work plan that indicates the sequence of earthwork grading, the number of "spreads" and the estimated quantities of daily earthwork to be performed prior to the commencement of grading. This work plan should be reviewed by the Geotechnical Consultant to schedule personnel to perform the appropriate level of observation, mapping, and compaction testing as necessary.

C. All clearing, site preparation, or earthwork performed on the project shall be conducted by the Contractor in accordance with the recommendations presented in the geotechnical report and under the observation of the Geotechnical Consultant.

D. It is the Contractor's responsibility to prepare the ground surface to receive the fills to the satisfaction of the Geotechnical Consultant and to place, spread, mix, water, and compact the fill in accordance with the specifications of the Geotechnical Consultant. The Contractor shall also remove all material considered unsatisfactory by the Geotechnical Consultant.

E. It is the Contractor's responsibility to have suitable and sufficient compaction equipment on the job site to handle the amount of fill being placed. If necessary, excavation equipment will be shut down to permit completion of compaction to project specifications. Sufficient watering apparatus will also be provided by the Contractor, with due consideration for the fill material, rate of placement, and time of year.

F. After completion of grading a report will be submitted by the Geotechnical Consultant.

II. SITE PREPARATION

A. Clearing and Grubbing

1. All vegetation such as trees, brush, grass, roots, and deleterious material shall be disposed of offsite. This removal shall be concluded prior to placing fill.

2. Any underground structures such as cesspools, cisterns, mining shafts, tunnels, septic tanks, wells, pipe lines, etc., are to be removed or treated in a manner prescribed by the Geotechnical Consultant.

III. FILL AREA PREPARATION

A. Remedial Removals/Overexcavations

1. Remedial removals, as well as overexcavation for remedial purposes, shall be evaluated by the Geotechnical Consultant. Remedial removal depths presented in the geotechnical report and shown on the geotechnical plans are estimates only. The actual extent of removal should be determined by the Geotechnical Consultant based on the conditions exposed during grading. All soft, loose, dry, saturated, spongy, organic-rich, highly fractured or otherwise unsuitable ground shall be overexcavated to competent ground as determined by the Geotechnical Consultant.

2. Soil, alluvium, or bedrock materials determined by the Soils Engineer as being unsuitable for placement in compacted fills shall be removed from the site. Any material incorporated as a part of a compacted fill must be approved by the Geotechnical Consultant.

3. Should potentially hazardous materials be encountered, the Contractor should stop work in the affected area. An environmental consultant specializing in hazardous materials should be notified immediately for evaluation and handling of these materials prior to continuing work in the affected area.

B. Evaluation/Acceptance of Fill Areas

All areas to receive fill, including removal and processed areas, key bottoms, and benches, shall be observed, mapped, elevations recorded, and/or tested prior to being accepted by the Geotechnical Consultant as suitable to receive fill. The contractor shall obtain a written acceptance from the Geotechnical Consultant prior to fill placement. A licensed surveyor shall provide sufficient survey control for determining locations and elevations of processed areas, keys, and benches.

C. Processing

After the ground surface to receive fill has been declared satisfactory for support of fill by the Geotechnical Consultant, it shall be scarified to a minimum depth of 6 inches and until the ground surface is uniform and free from ruts, hollows, hummocks, or other uneven features which may prevent uniform compaction.

The scarified ground surface shall then be brought to optimum moisture, mixed as required, and compacted to a minimum relative compaction of 90 percent.

D. Subdrains

Subdrainage devices shall be constructed in compliance with the ordinances of the controlling governmental agency, and/or with the recommendations of the Geotechnical Consultant. (Typical Canyon Subdrain details are given on Plate SG-1).

E. Cut/Fill & Deep Fill/Shallow Fill Transitions

In order to provide uniform bearing conditions in cut/fill and deep fill/shallow fill transition lots, the cut and shallow fill portions of the lot should be overexcavated to the depths and the horizontal limits discussed in the approved geotechnical report and replaced with compacted fill. (Typical details are given on Plate SG-7.)

STANDARD GRADING SPECIFICATIONS

IV. COMPACTED FILL MATERIAL

A. General

Materials excavated on the property may be utilized in the fill, provided each material has been determined to be suitable by the Geotechnical Consultant. Material to be used for fill shall be essentially free of organic material and other deleterious substances. Roots, tree branches, and other matter missed during clearing shall be removed from the fill as recommended by the Geotechnical Consultant. Material that is spongy, subject to decay, or otherwise considered unsuitable shall not be used in the compacted fill.

Soils of poor quality, such as those with unacceptable gradation, high expansion potential, or low strength shall be placed in areas acceptable to the Geotechnical Consultant or mixed with other soils to achieve satisfactory fill material.

B. Oversize Materials

Oversize material defined as rock, or other irreducible material with a maximum dimension greater than 12 inches in diameter, shall be taken offsite or placed in accordance with the recommendations of the Geotechnical Consultant in areas designated as suitable for rock disposal (Typical details for Rock Disposal are given on Plate SG-4).

Rock fragments less than 12 inches in diameter may be utilized in the fill provided, they are not nested or placed in concentrated pockets; they are surrounded by compacted fine grained soil material and the distribution of rocks is approved by the Geotechnical Consultant.

C. Laboratory Testing

Representative samples of materials to be utilized as compacted fill shall be analyzed by the laboratory of the Geotechnical Consultant to determine their physical properties. If any material other than that previously tested is encountered during grading, the appropriate analysis of this material shall be conducted by the Geotechnical Consultant as soon as possible.

D. Import

If importing of fill material is required for grading, proposed import material should meet the requirements of the previous section. The import source shall be given to the Geotechnical Consultant at least 2 working days prior to importing so that appropriate tests can be performed and its suitability determined.

V. FILL PLACEMENT AND COMPACTION

A. Fill Layers

Material used in the compacting process shall be evenly spread, watered, processed, and compacted in thin lifts not to exceed 6 inches in thickness to obtain a uniformly dense layer. The fill shall be placed and compacted on a horizontal plane, unless otherwise approved by the Geotechnical Consultant.

B. Moisture Conditioning

Fill soils shall be watered, dried back, blended, and/or mixed, as necessary to attain a relatively uniform moisture content at or slightly above optimum moisture content.

C. Compaction

Each layer shall be compacted to 90 percent of the maximum density in compliance with the testing method specified by the controlling governmental agency. (In general, ASTM D 1557-02, will be used.)

If compaction to a lesser percentage is authorized by the controlling governmental agency because of a specific land use or expansive soils condition, the area to received fill compacted to less than 90 percent shall either be delineated on the grading plan or appropriate reference made to the area in the soils report.

D. Failing Areas

If the moisture content or relative density varies from that required by the Geotechnical Consultant, the Contractor shall rework the fill until it is approved by the Geotechnical Consultant.

E. Benching

All fills shall be keyed and benched through all topsoil, colluvium, alluvium or creep material, into sound bedrock or firm material where the slope receiving fill exceeds a ratio of 5 horizontal to 1 vertical, in accordance with the recommendations of the Geotechnical Consultant.

VI. SLOPES

A. Fill Slopes

The contractor will be required to obtain a minimum relative compaction of 90 percent out to the finish slope face of fill slopes, buttresses, and stabilization fills. This may be achieved by either overbuilding the slope and cutting back to the compacted core, or by direct compaction of the slope face with suitable equipment, or by any other procedure that produces the required compaction.

B. Side Hill Fills

The key for side hill fills shall be a minimum of 15 feet within bedrock or firm materials, unless otherwise specified in the soils report. (See detail on Plate SG-5.)

C. Fill-Over-Cut Slopes

Fill-over-cut slopes shall be properly keyed through topsoil, colluvium or creep material into rock or firm materials, and the transition shall be stripped of all soils prior to placing fill. (see detail on Plate SG-6).

D. Landscaping

All fill slopes should be planted or protected from erosion by other methods specified in the soils report.

E. Cut Slopes

1. The Geotechnical Consultant should observe all cut slopes at vertical intervals not exceeding 10 feet.

2. If any conditions not anticipated in the preliminary report such as perched water, seepage, lenticular or confined strata of a potentially adverse nature, unfavorably inclined bedding, joints or fault planes are encountered during grading, these conditions shall be evaluated by the Geotechnical Consultant, and recommendations shall be made to treat these problems (Typical details for stabilization of a portion of a cut slope are given in Plates SG-2 and SG-3.).

3. Cut slopes that face in the same direction as the prevailing drainage shall be protected from slope wash by a non-erodible interceptor swale placed at the top of the slope.

4. Unless otherwise specified in the soils and geological report, no cut slopes shall be excavated higher or steeper than that allowed by the ordinances of controlling governmental agencies.

5. Drainage terraces shall be constructed in compliance with the ordinances of controlling governmental agencies, or with the recommendations of the Geotechnical Consultant.

VII. GRADING OBSERVATION

A. General

All cleanouts, processed ground to receive fill, key excavations, subdrains, and rock disposals must be observed and approved by the Geotechnical Consultant prior to placing any fill. It shall be the Contractor's responsibility to notify the Geotechnical Consultant when such areas are ready.

B. Compaction Testing

Observation of the fill placement shall be provided by the Geotechnical Consultant during the progress of grading. Location and frequency of tests shall be at the Consultants discretion based on field conditions encountered. Compaction test locations will not necessarily be selected on a random basis. Test locations may be selected to verify adequacy of compaction levels in areas that are judged to be susceptible to inadequate compaction.

C. Frequency of Compaction Testing

In general, density tests should be made at intervals not exceeding 2 feet of fill height or every 1000 cubic yards of fill placed. This criteria will vary depending on soil conditions and the size of the job. In any event, an adequate number of field density tests shall be made to verify that the required compaction is being achieved.

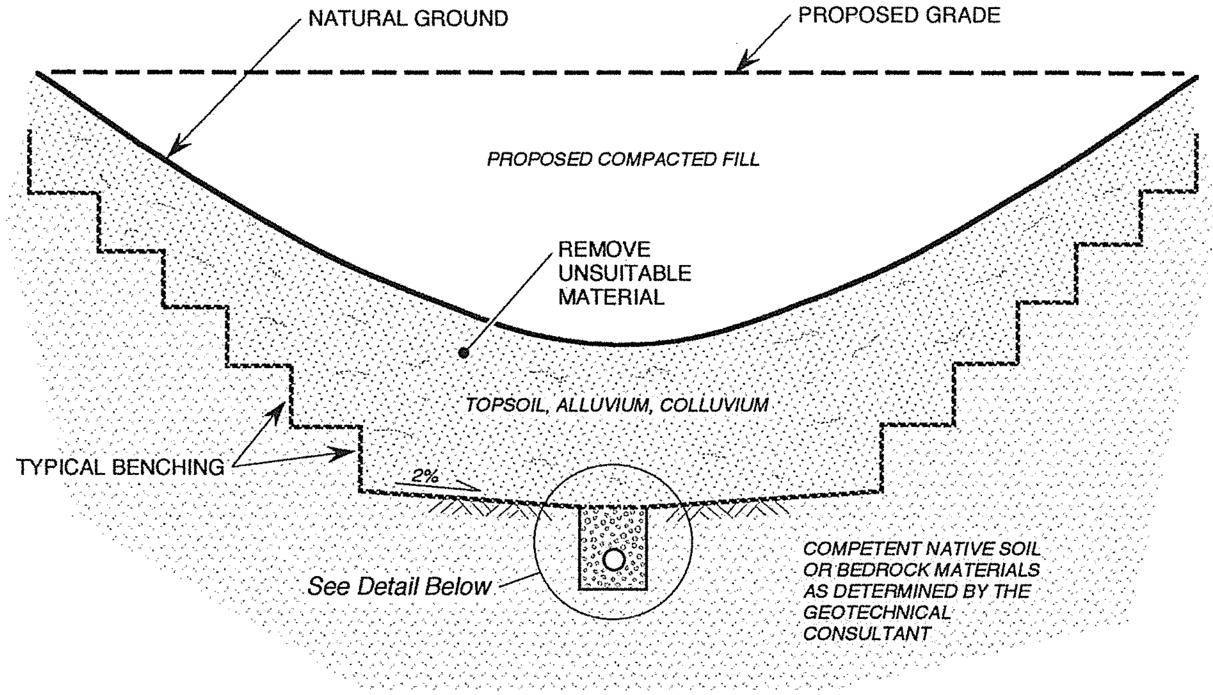
VIII. CONSTRUCTION CONSIDERATIONS

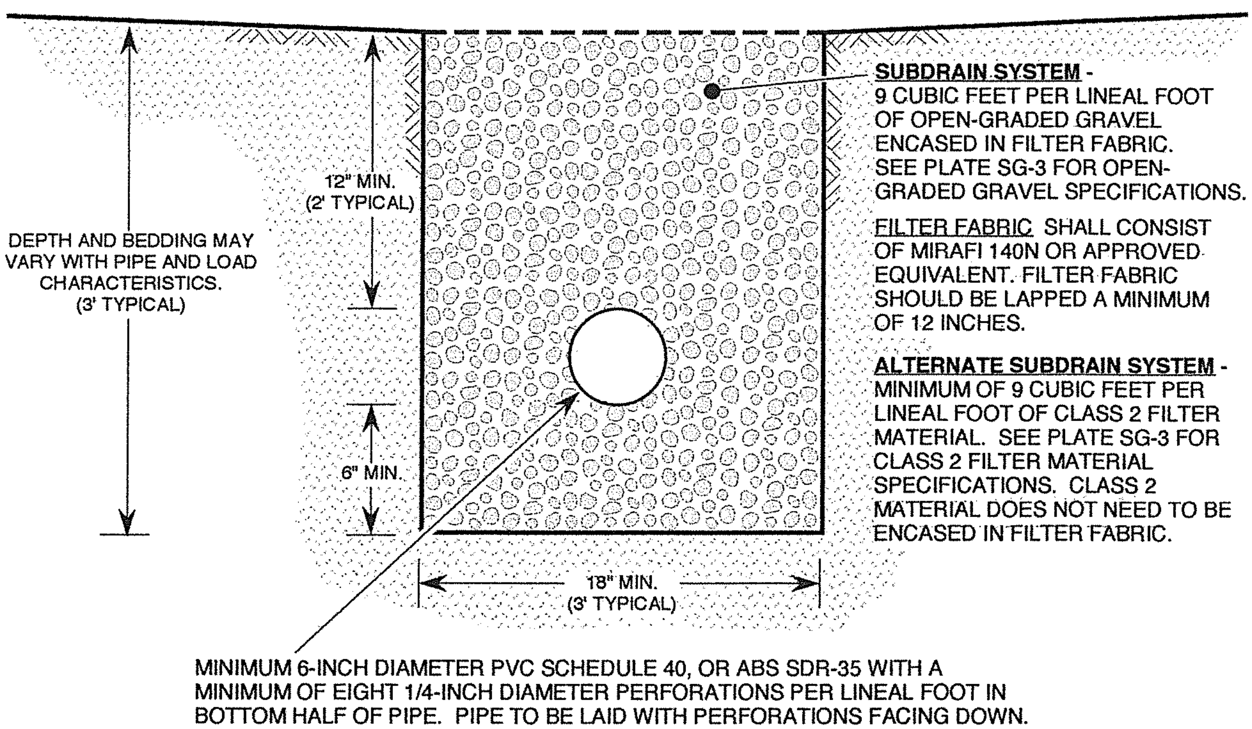
A. Erosion control measures, when necessary, shall be provided by the Contractor during grading and prior to the completion and construction of permanent drainage controls.

B. Upon completion of grading and termination of observations by the Geotechnical Consultant, no further filling or excavating, including that necessary for footings, foundations, large tree wells, retaining walls, or other features shall be performed without the approval of the Geotechnical Consultant.

C. Care shall be taken by the Contractor during final grading to preserve any berms, drainage terraces, interceptor swales, or other devices of permanent nature on or adjacent to the property.

S:\!BOILERS-WORK\REPORT INSERTS\STANDARD GRADING SPECS

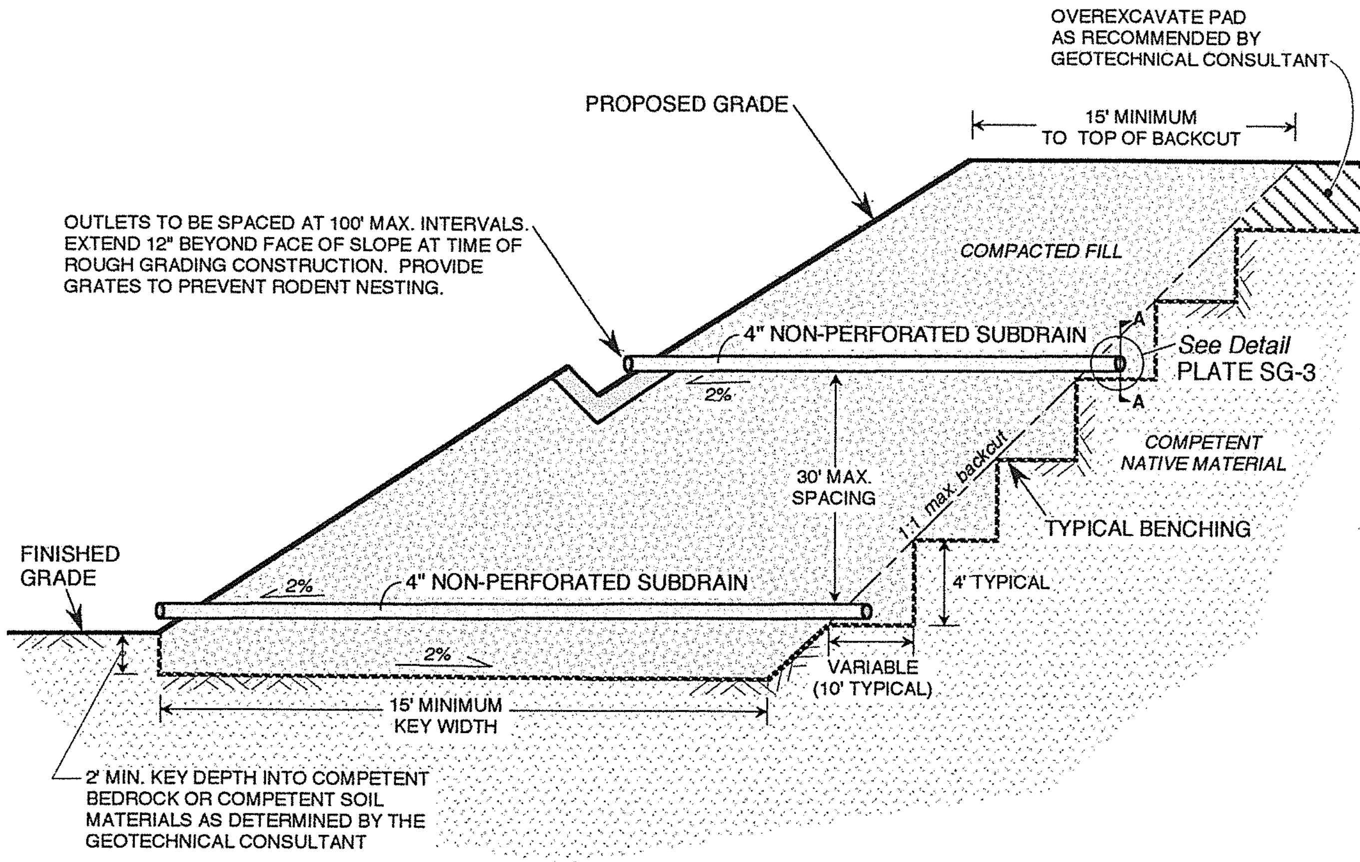




NOTES:

1. FOR CONTINUOUS RUNS IN EXCESS OF 500 FEET USE 8-INCH DIAMETER PIPE.
2. FINAL 20 FEET OF PIPE AT OUTLET SHALL BE NON-PERFORATED AND BACKFILLED WITH FINE-GRAINED MATERIAL.

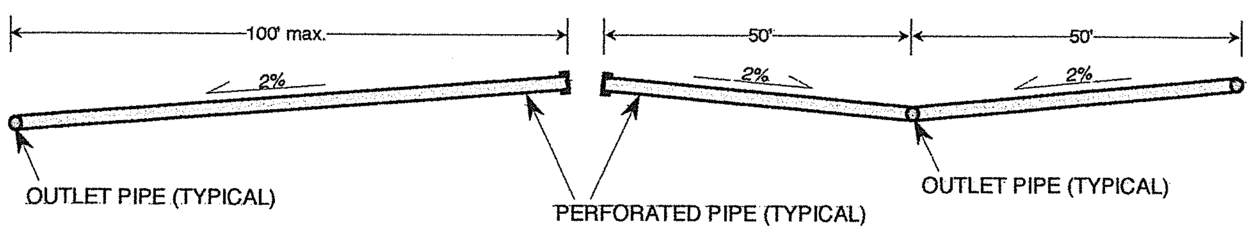
PETRA	CANYON SUBDRAIN DETAIL	PLATE SG-1



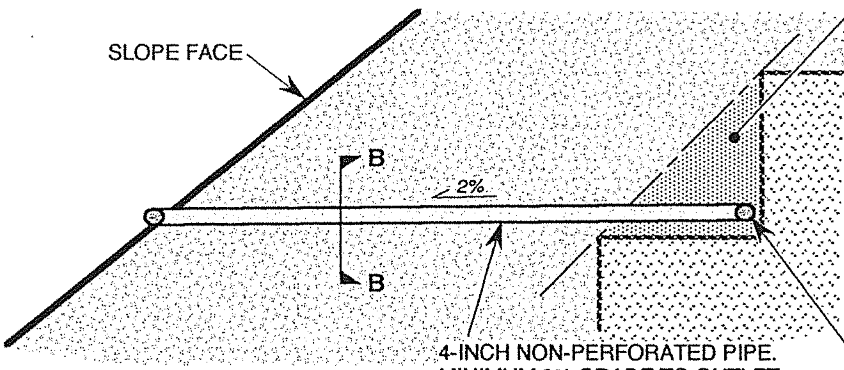
NOTES:

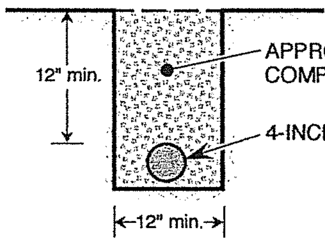
1. 30' MAXIMUM VERTICAL SPACING BETWEEN SUBDRAIN SYSTEMS.
2. 100' MAXIMUM HORIZONTAL DISTANCE BETWEEN NON-PERFORATED OUTLET PIPES. *(See Below)*
3. MINIMUM GRADIENT OF 2% FOR ALL PERFORATED AND NON-PERFORATED PIPE.

SECTION A-A (PERFORATED PIPE PROFILE)



PETRA	BUTTRESS OR STABILIZATION FILL DETAIL	PLATE SG-2





SECTION B-B (OUTLET PIPE)

PIPE SPECIFICATIONS:

1. 4-INCH MINIMUM DIAMETER, PVC SCHEDULE 40 OR ABS SDR-35.
2. FOR PERFORATED PIPE, MINIMUM 8 PERFORATIONS PER FOOT ON BOTTOM HALF OF PIPE.

FILTER MATERIAL/FABRIC SPECIFICATIONS:

OPEN-GRADED GRAVEL ENCASED IN FILTER FABRIC.
(MIRAFI 140N OR EQUIVALENT)

OPEN-GRADED GRAVEL

SIEVE SIZE	PERCENT PASSING
1 1/2-INCH	88 - 100
1-INCH	5 - 40
3/4-INCH	0 - 17
3/8-INCH	0 - 7
No. 200	0 - 3

ALTERNATE:

CLASS 2 PERMEABLE FILTER MATERIAL PER CALTRANS STANDARD SPECIFICATION 68-1.025.

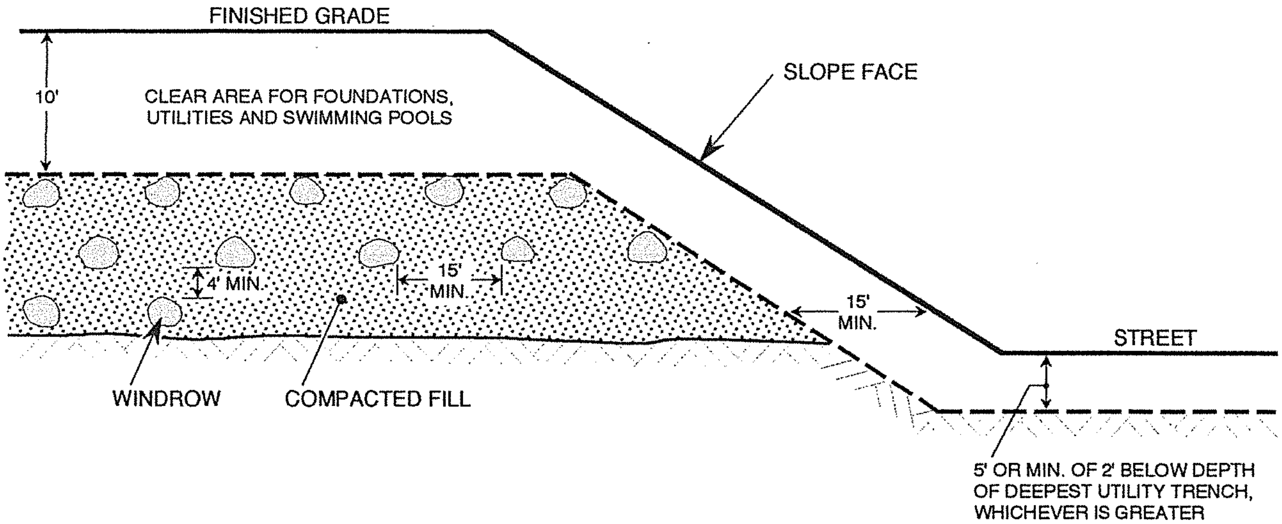
CLASS 2 FILTER MATERIAL

SIEVE SIZE	PERCENT PASSING
1-INCH	100
3/4-INCH	90 - 100
3/8-INCH	40 - 100
No. 4	25 - 40
No. 8	18 - 33
No. -30	5 - 15
No. -50	0 - 7
No. 200	0 - 3

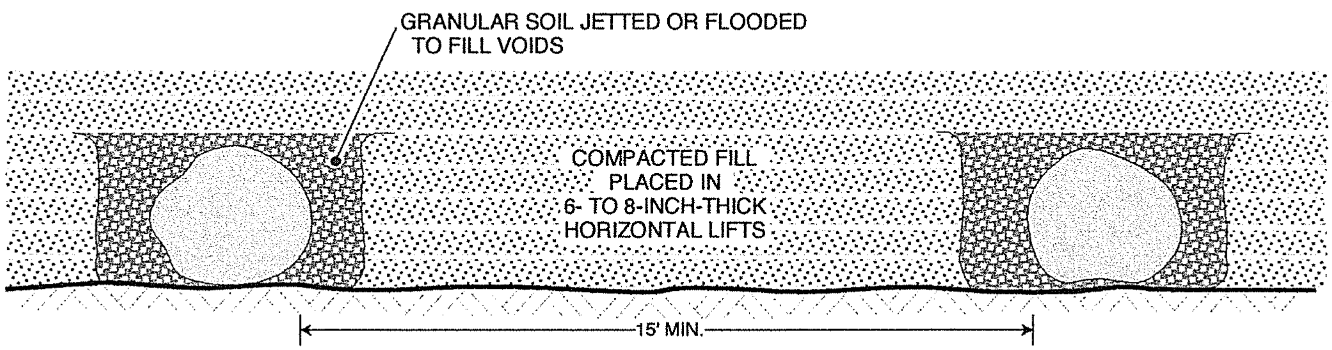
PETRA

BUTTRESS OR STABILIZATION FILL SUBDRAIN

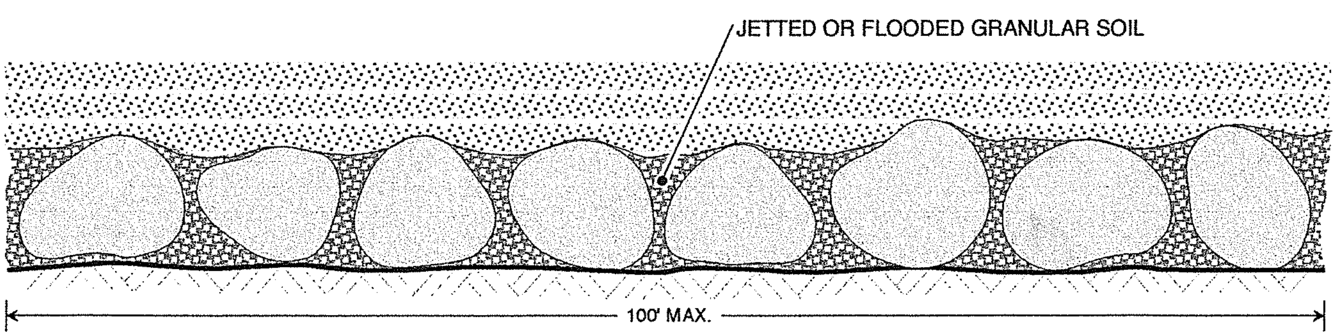
PLATE SG-3



TYPICAL WINDROW DETAIL (END VIEW)

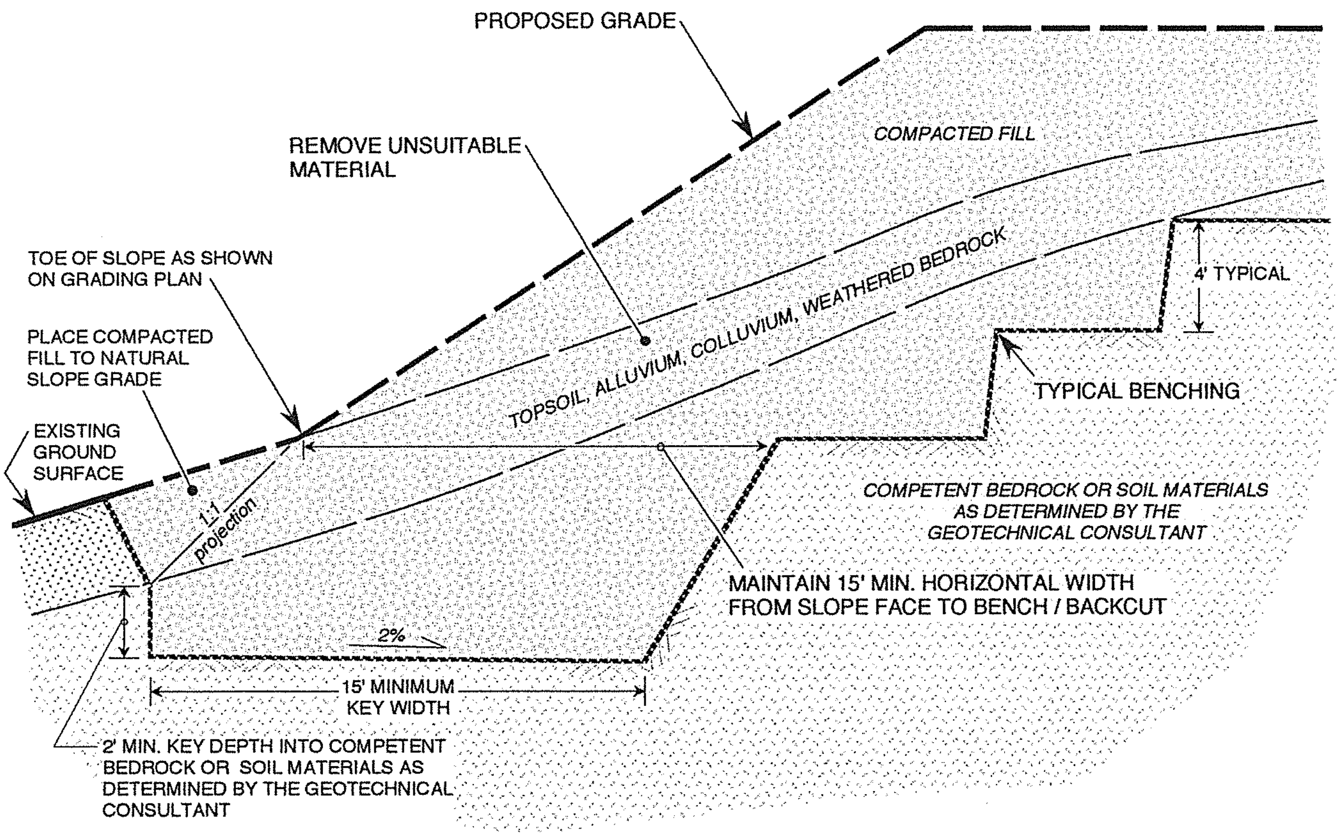


TYPICAL WINDROW DETAIL (PROFILE VIEW)



NOTE: OVERSIZE ROCK IS DEFINED AS CLASTS HAVING A MAXIMUM DIMENSION OF 12" OR LARGER

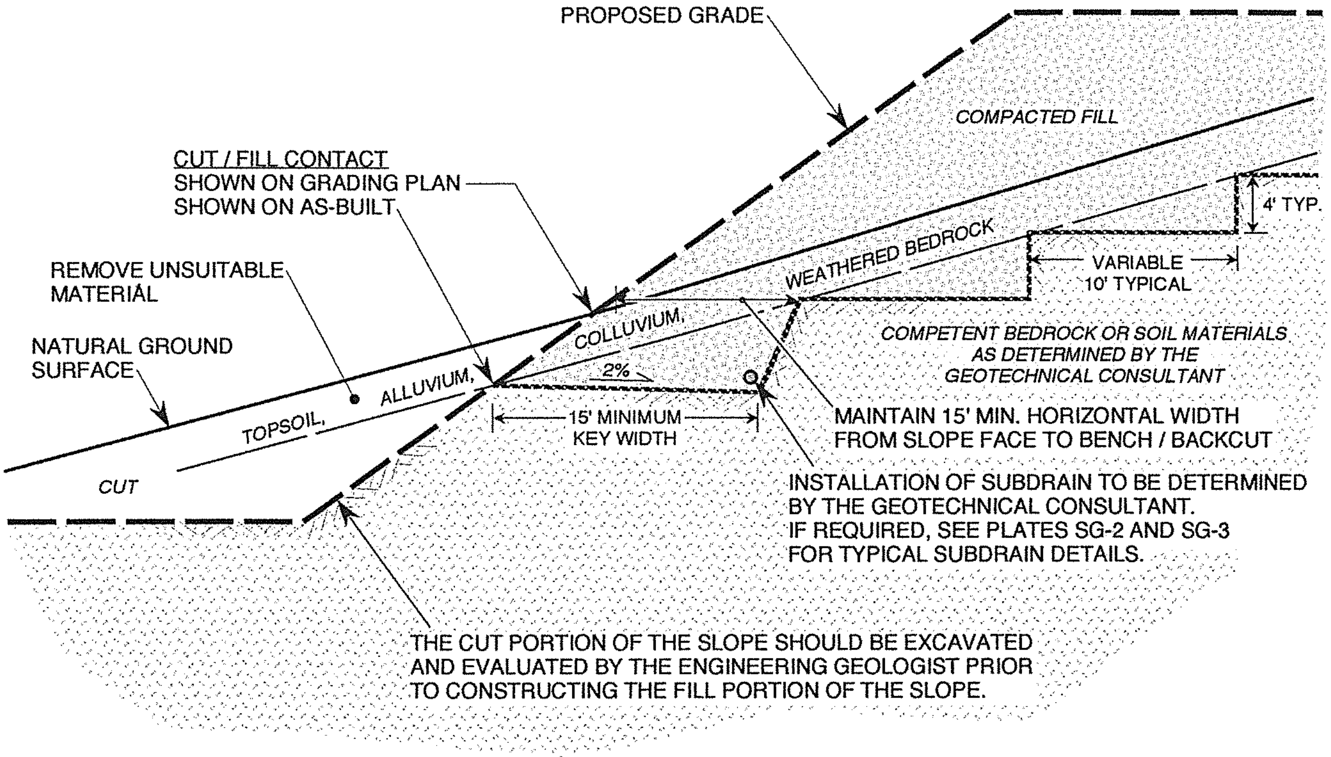
PETRA	TYPICAL ROCK DISPOSAL DETAIL	PLATE SG-4



NOTES:

1. WHERE NATURAL SLOPE GRADIENT IS 5:1 OR LESS, BENCHING IS NOT NECESSARY; HOWEVER, FILL IS NOT TO BE PLACED ON COMPRESSIBLE OR UNSUITABLE MATERIAL.
2. SOILS ENGINEER TO DETERMINE IF SUBDRAIN IS REQUIRED.

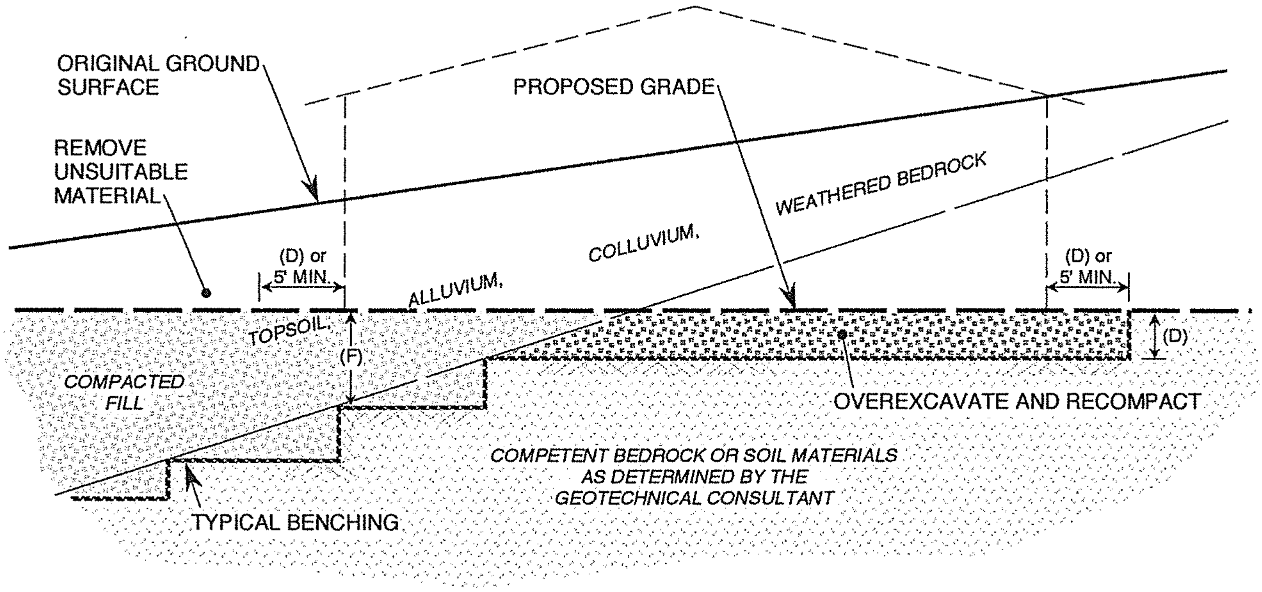
PETRA	FILL SLOPE ABOVE NATURAL SLOPE	PLATE SG-5



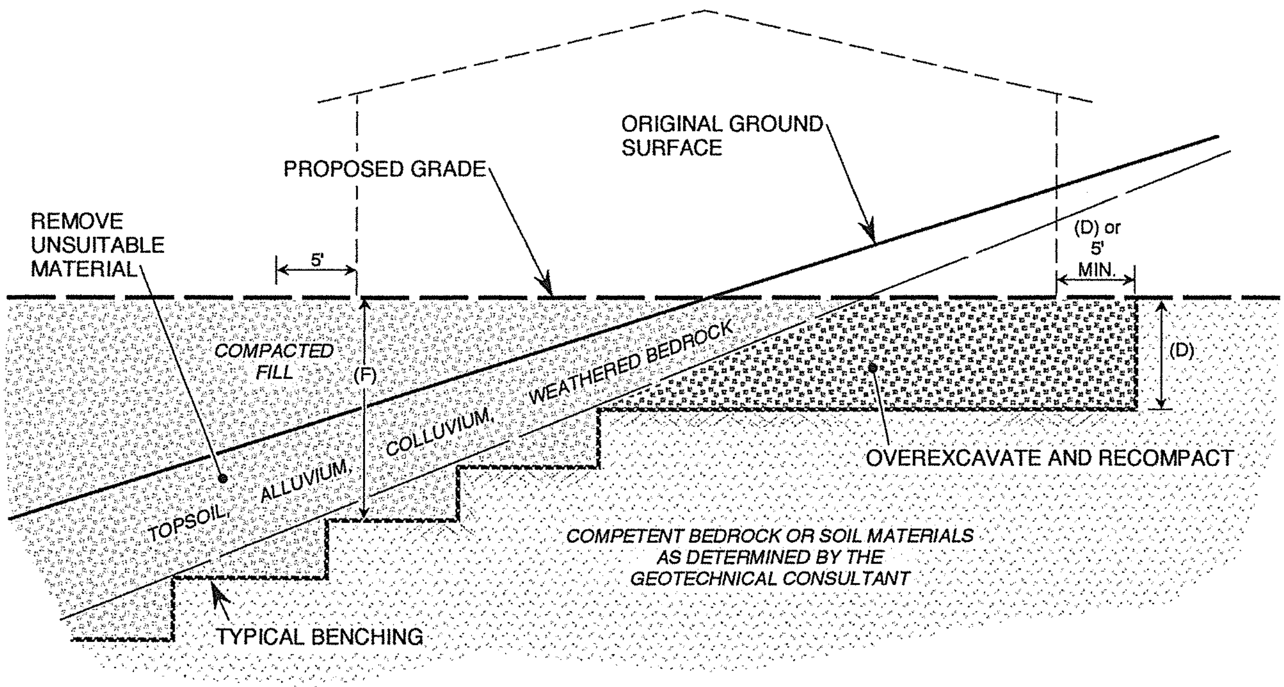
PETRA	**FILL SLOPE ABOVE CUT SLOPE**	**PLATE SG-6**

CUT LOT

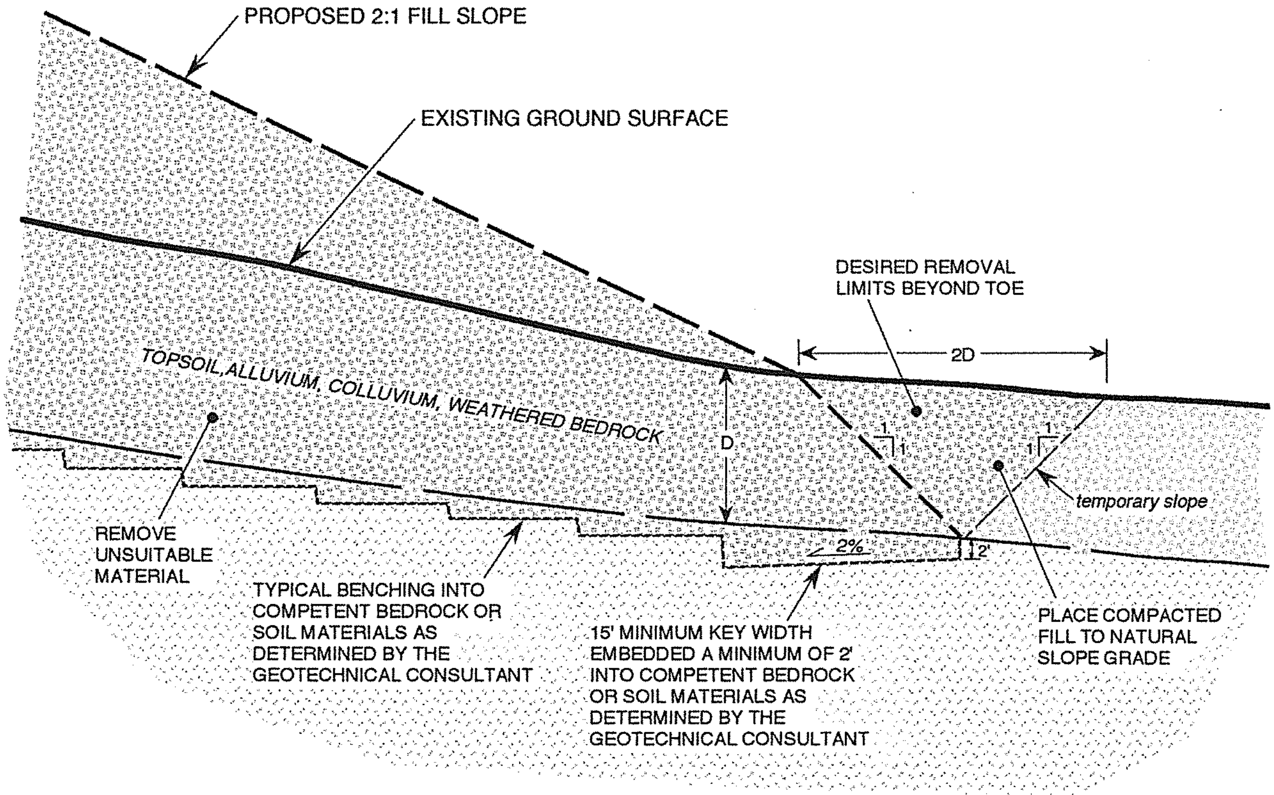
UNSUITABLE MATERIAL EXPOSED IN PORTION OF CUT PAD



CUT-FILL TRANSITION LOT

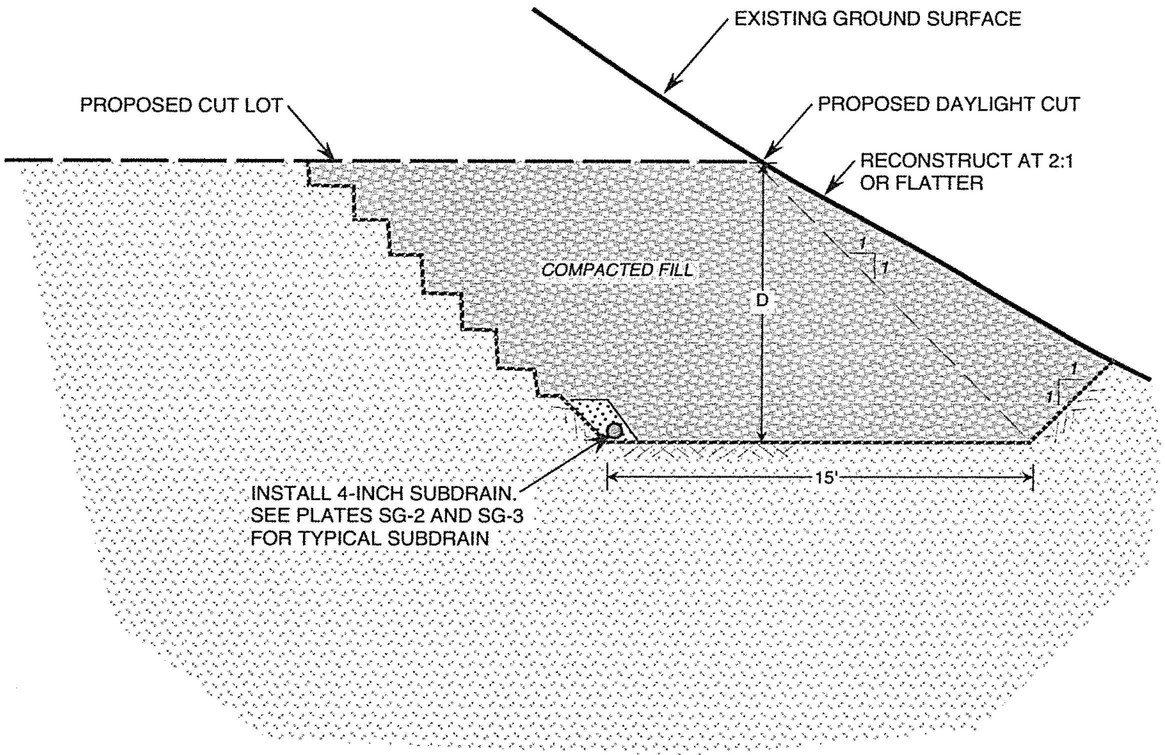


MAXIMUM FILL THICKNESS (F)	DEPTH OF OVEREXCAVATION (D)
FOOTING DEPTH TO 3 FEET	EQUAL DEPTH
3 TO 6 FEET	3 FEET
GREATER THAN 6 FEET	1/2 THE THICKNESS OF DEEPEST FILL PLACED WITHIN THE "FILL" PORTION (F) TO 15 FEET MAXIMUM



D = RECOMMENDED DEPTH OF REMOVAL
PER GEOTECHNICAL REPORT

PETRA	TYPICAL REMOVALS BEYOND TOE OF PROPOSED FILL SLOPE	PLATE SG-8



NOTE:

1. "D" SHALL BE 10 FEET MINIMUM OR AS DETERMINED BY SOILS ENGINEER.

PETRA	SHEAR KEY ON DAYLIGHT CUT LOTS	PLATE SG-9