Appendix 4.16A ENGEO Incorporated. 2009. Geotechnical Investigation. Potrero Annex and Terrace Redevelopment, San Francisco, CA. July 10. Submitted to BRIDGE Housing.

GEOTECHNICAL EXPLORATION

POTRERO ANNEX AND TERRACE REDEVELOPMENT
SAN FRANCISCO, CA

Submitted to:

Ms. Lisa Grady
Bridge Housing
345 Spear Street, Suite 700
San Francisco, CA 94105

July 10, 2009
Project No. 8683.000.000

- Expect Excellence -

ENGEO INCORPORATED

GEOTECHNICAL
ENVIRONMENTAL
WATER RESOURCES
CONSTRUCTION SERVICES

Project No.
8683.000.000

July 10, 2009

Ms. Lisa Grady
Bridge Housing
345 Spear Street, Suite 700
San Francisco, CA 94105

Subject: Potrero Annex and Terrace Redevelopment
San Francisco, California

GEOTECHNICAL EXPLORATION

Dear Ms. Grady:

With your authorization, we have conducted a geotechnical exploration for the planned redevelopment of the Potrero Annex and Terrace housing project in San Francisco, California. The accompanying report presents the results of our site exploration, the analysis of the geotechnical and geologic data accumulated during the study and the geotechnical recommendations for design of the proposed residential development. Based on our findings, it is our opinion that the currently proposed development is feasible from a geotechnical standpoint provided the recommendations included in this report are followed.

We are pleased to provide our services to you on this project and look forward to consulting further with you and your design team.

Sincerely,

ENGEO Incorporated

Brian Flaherty, CEG

Donald E. Bruggers, GE

REGISTERED PROFESSIONAL ENGINEER
DONALD BRUGGERS
No. 2094
Exp. 12/31/2011
GEOTECHNICAL
STATE OF CALIFORNIA

ebf/deb/cjn

TABLE OF CONTENTS

Letter of Transmittal

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of this geotechnical exploration is to evaluate the geotechnical and geologic conditions within the planned redevelopment areas within the Potrero Annex and Terrace housing project in San Francisco, California, and provide preliminary grading and foundation recommendations for the design and construction of the proposed residential redevelopment.

The scope of our services included: review of available literature and geologic maps for the immediate area, subsurface exploration consisting of seven soil borings and nine test pits, laboratory testing of materials sampled during the field exploration, geotechnical data analyses, characterization of soil, bedrock and groundwater conditions at the site and report preparation summarizing our recommendations for proposed site development.

We prepared this report exclusively for Bridge Housing and their design team consultants. ENGEO Incorporated should review any changes made in the character, design or layout of the development to modify the conclusions and recommendations contained in this report, as necessary. This document may not be reproduced in whole or in part by any means whatsoever, nor may it be quoted or excerpted without the express written consent of ENGEO.

1.2 SITE LOCATION AND DESCRIPTION

The approximately 32-acre site, located in the Potrero Hill neighborhood of San Francisco, is generally bounded by Wisconsin Street to the west, 25th Street to the south, and the Potrero Recreation Center and 22nd Street to the north. The eastern edge of the property sits on a ridge paralleling Pennsylvania Street below. Site boundaries extend to Wisconsin Street on the west to 22rd Street to the north and extending from 23rd Street north along Missouri Street (Figure 1). The eastern property includes Texas Street south to 25th Street. The southern limits of the redevelopment area include a rectangular parcel bounded by 25th Street to the north, Connecticut Street to the east, 26th Street to the south and Wisconsin Street to the west.

The topographic relief of the redevelopment area is very steep in places with grades exceeding 30% in some locations. Review of a site topographic plan provided by the project architect shows the highest site elevation at the intersection of 23rd Street and Arkansas in the north at 265 feet above mean sea level (msl). The lowest topographic elevation of 40 feet above msl is in the southern portion of the redevelopment area at the intersection of 26th Street and Connecticut Street.

The 32-acre property is currently occupied by 606 public housing units and related landscape and hardscape. It is our understanding that the units were constructed in two phases: the first, The Terraces, contained 469 units and was constructed in 1941; the second, known as the Annex, contains 137 units and was constructed in 1955. Earthwork with engineered cuts and fills was likely undertaken, along with the construction of concrete retaining walls, to create the terraced building pads and parking areas.

1.3 PROPOSED DEVELOPMENT

It is currently planned to revitalize the Potrero Annex and Terrace neighborhood with the replacement of the 606 existing units of public housing. In addition the current plan anticipates the development of an additional 200 affordable rental units and approximately 300 market rate for-sale units. The anticipated building type in the new community will be a combination of Type V and Type II construction. The redevelopment site will include new public infrastructure, such as streets, sidewalks and utilities, as well as additional community amenities such as open space, childcare facilities, office space for social services and management functions, and recreational facilities. Green streets and open spaces with permeable pavement, vegetative swales and other stormwater management strategies will also be considered in the final site design.

2.0 GEOLOGY AND SEISMICITY

2.1 REGIONAL GEOLOGIC HISTORY

The site is located on the San Francisco Peninsula, on the western side of the California Coast Ranges geomorphic province. The Coast Ranges are a complex series of linear mountain ranges that lie more-or-less parallel to the coast and to the San Andreas Fault System. The Coast Ranges are composed primarily of Jurassic and Cretaceous-age rocks that accumulated on the sea floor and were later scraped off when the ocean plate on which they originated was subducted beneath North America. These older rocks include a tectonic mix of sandstone, chert, altered basalt referred to as greenstone, and serpentinite, collectively referred to as the Franciscan Complex. While Franciscan bedrock is exposed in the hills and cliffs of San Francisco, the flanks of the hills are blanketed with thin to thick layers of colluvium and alluvium (weathered material washed downslope from the bedrock exposures). Valleys are filled with water-laid stream deposits.

2.2 SITE SOILS AND GEOLOGY

The geology in the area of the property and vicinity has been mapped on a regional scale by Schlocker(1958) The geologic units mapped underlying the site are described as sheared to badly sheared serpentine within the Cretaceous and Jurassic Franciscan Complex (sp, Figure 4), which is consistent with observed outcrops and boring samples. The serpentine is found primarily as hard blocks in a soft, waxy and crumbly matrix of weathered bedrock.

2.3 SITE SEISMICITY

No known active[1] faults cross the property and the site is not located within an Alquist-Priolo Earthquake Fault Zone; however, large (>Mw7) earthquakes have historically occurred in the

[1] An active fault is defined by the State Mining and Geology Board as one that has had surface displacement within Holocene time (about the last 11,000 years). The State of California has prepared maps designating zones for special studies that contain these active earthquake faults.

Bay Area and many earthquakes of low magnitude occur every year. According to the USGS, the closest known active (surface) faults to the site are the San Andreas Fault, located about 6 miles (10 km) to the southwest, the San Gregorio fault located about 10 miles (16 km) to the west and the Hayward fault located about 11 miles (18 km) to the east. These faults have estimated maximum moment magnitudes (Mw) of 7.9, 7.2 and 7.1, respectively (WGCEP, 2007).

Many earthquakes of low magnitude occur every year throughout the region; most are concentrated along the San Andreas, Hayward and Calaveras faults. Figure 5 shows the approximate location of Quaternary faults and significant historic earthquakes mapped within the San Francisco Bay Region.

In addition, the Working Group on California Earthquake Probabilities (2007) estimates there is a 21 percent probability that a magnitude Mw = 6.7 or greater earthquake will occur on the northern portion of the San Andreas Fault, while they estimate a 31 percent probability of the same magnitude event occurring on the Hayward/Rogers Creek Fault within 30 years of their study (2007 – 2037).

3.0 FIELD EXPLORATION

The field exploration for this study was conducted on June 16, 2009, and consisted of drilling seven exploratory borings and excavating nine exploratory test pits to depths ranging from approximately 3 to 16.5 feet below grade at the locations shown on the Site Plan, Figure 3. Test borings were drilled using a truck-mounted B-24 drill rig equipped with 4-inch-diameter continuous flight augers. Soil samples recovered during drilling were retrieved using a 3-inch outside diameter (O.D.) California-type split-spoon sampler fitted with 6-inch-long brass liners. The samplers were driven with a 140-pound safety hammer falling a distance of 30 inches. A rope and cat-head system was used to lift the safety hammer during our exploration. The penetration of the samplers into the native materials was field recorded as the number of blows needed to drive the sampler 18 inches in 6-inch increments. The boring logs show the number of blows required for the last 1 foot of penetration, and the blow counts have not been converted using any correction factors.

Borings were logged in the field by an ENGEO engineer. The field logs were then used to develop the report Boring Logs reported in Appendix A. The logs depict subsurface conditions within the borings for the date of drilling; however, subsurface conditions may vary with time.

A backhoe was used to excavate the nine exploratory test pits shown on Figure 3. An ENGEO geologist worked with the backhoe operator to locate the test pits in accessible areas of the site in order to access subsurface information where the rig could not drill. The test pits were logged by our geologist to depict subsurface conditions within the excavations. This information was used in the preparation of the Geologic Map shown in Figure 6. The test pit logs are presented in Appendix B.

3.1 SUBSURFACE CONDITIONS

A geologic map of the redevelopment project (Figure 5) was developed based on our review of published geologic maps, examination of aerial photographs, site reconnaissance and review of the findings of our subsurface exploration. Regional geologic mapping by Schlocker, 1958 (Figure 4) was the initial basis for the geologic mapping units that have been used.

The geologic map conveys our current understanding of the distribution of artificial fill, soil and bedrock types with similar engineering properties that is useful for development of a successful grading and foundation design strategy for the project. Previous grading activities appear to have resulted in the placement of fill beneath Connecticut Street and along the side yard slopes between the structures along Connecticut Street. In addition, it appears that fill was also placed on portions of the slope east of the northern limits of Texas Street and east of the Missouri Street and Texas Street intersection (Figure 5). The earlier grading created other numerous sliver fills associated with the construction of the side yard retaining walls especially along Connecticut and south of 25th Street. It was not our intention to try and map all of the fills on-site but to identify and depict the larger fill areas that are significant to this project.

No records pertaining to the placement of the existing fill had been found at the time this report was prepared. In general, our exploration encountered fill consisting of silty clay and sand and clayey silt and sand ranging in thickness from 1 to 8 feet. Conditions observed in the borings and test pits suggest that the fills were compacted to some degree and many of the existing fills appear to be performing in a satisfactory manner. However, it appears unlikely that the fills were constructed with keyways, benching and subdrains, etc. that are required for engineered fill designed to current standards.

Slope wash and colluvium are materials transported by erosion from slopes and ridges that are typically deposited in swales. A layer of colluvium or slope wash was exposed in borings B-3 and B-4 drilled along Connecticut Street. This very stiff to hard silty clay ranged in thickness from 11 feet in boring B-3 to about 6 feet in B-4. Laboratory testing of the sample of the clay materials from B-3 was found to have a Plasticity Index of 57 which indicates the clay is highly expansive in some locations.

Serpentinite bedrock was encountered in each of the exploratory borings and test pits. Bedrock in many locations was exposed at or within 2.5 feet of the ground surface. In the area of the fill along Connecticut Street, bedrock was found at depths of 11 to 15 feet.

Extensive exposures of serpentinite bedrock (SP) are evident on existing cut slopes and in sporadic outcrops within the site. Areas where bedrock is currently exposed are shown on the Site Geologic Map, Figure 5. The friable to very strong bedrock varies from light green to mottled gray in color. Bedrock structure is somewhat chaotic with fractures and foliations in various directions. Localized zones of hard serpentinite bedrock, ranging up to about 20 feet in diameter, were observed on the exposed cut slopes along the eastern property limits.

The serpentine was further characterized into four subclasses of rock based on engineering and geological characteristics (Figure 5) and are described as follows:

- SP-1, (Blocky). Mottled gray, pale green with brown iron oxide staining on fracture surfaces, medium strong, highly weathered, very closely fractured, abundant pale green coatings on fracture surfaces.

- SP-2, (Blocky, lower degree of alteration). Mottled dark gray with pale green coatings on fractures, medium strong to strong, moderately weathered very closely fractured, occasional slickensided surfaces.

- SP-3, (Reddish Brown). Mottled dark grayish green and reddish brown, strong to very strong, moderately weathered within upper foot and slightly weathered below. Moderately fractured, some iron oxide staining on fracture surfaces.

- SP-4, (Pale Blue). Mottled dark gray and pale blue, moderately strong, moderately to highly weathered, closely fractured, some iron oxide staining on fracture surfaces, occasional slickensided surfaces with pale green coating

Laboratory analysis of the near surface sandy silt (Boring B-2) and the deeper weathered serpentine (Boring B-7) indicates that the plasticity indices range from 9 to 11 suggesting that these materials have a low expansion potential. The colluvial deposit encountered in boring B-3 had a plasticity index of 57 indicating that this material has a high expansion potential. Laboratory testing of plasticity indices are provided in Appendix C of this report.

The geologic setting is one of high variability. It is common in Franciscan bedrock for geologic units to contain a mixture of rock types and variable rock properties. For example, where serpentinite rock has been mapped, it is possible that some localized zones or lenses of shale, graywacke or greenstone may be encountered.

No groundwater was encountered in either the exploratory borings or test pits. It should be recognized that fluctuations in the level of groundwater may occur due to variations in rainfall, irrigation practice and other factors not evident at the time measurements were made. The boreholes were backfilled on the day of drilling with cement grout materials approved by the City and County of San Francisco Department of Public Health.

4.0 DISCUSSION AND CONCLUSIONS

The site was evaluated with respect to known geologic hazards common to the San Francisco Bay Regions. The primary hazards identified and the risks associated with these hazards with respect to the planned development are discussed in the following sections of this report.

4.1 EXISTING FILL AND LOOSE SURFACE SOILS

As discussed, the existing fills have not been constructed and documented in a manner that is consistent with current standards for engineered fill. The character of the existing fills could vary widely in terms of material type, thickness, in-place density and placement methods. Based on a review of the findings of our exploration, the areas of the fill, which in some locations is up to at least 6 feet in thickness, and the upper 2 to 3 feet of soil above the bedrock is generally loose to medium dense in consistency. To reduce the potential for adverse settlement or stability problems, we recommend that the fill and loose surface soil within proposed development areas be removed and replaced as engineered fill. Soil materials free of deleterious debris may be reused on-site as engineered fill.

4.2 SOIL CREEP

Clayey soils on steeper natural slopes are subject to soil creep. Soil creep is the slow down-slope movement of soil that occurs with the annual cycle of wetting and drying under the influence of gravity. The potential for adverse impacts from soil creep can be minimized by a combination of benching through the surficial soil during fill placement, soil compaction, foundation selection and structure setbacks, as recommended in this report.

4.3 EXPANSIVE SOILS

Expansive soils shrink and swell as a result of moisture changes. This can cause heaving and cracking of slabs-on-grade, pavements and foundations. Building damage due to volume changes associated with expansive soils can be reduced by: (1) selectively placing the higher on-site expansive materials in the deeper fill areas (generally at depths below 10 feet of finished grades), or placing these higher expansive on-site materials outside of areas of the proposed structures and site improvements (such as landscape areas); (2) performing proper moisture conditioning and compaction of fill materials within selected ranges to reduce their swell potential; and (3) using deep foundations, structurally reinforced “rigid” mats, or post-tensioned slabs designed to resist the uplift pressures and deflections associated with the soil expansion. Foundation criteria are further discussed in the "Foundation Design” section of this report.

We found the highly expansive colluvial soil and slope wash beneath the fill on Connecticut Street. If final plan grades expose this soil at or near the final design grades, corrective grading will be required to reduce the potential for soil swell and its possible impacts to the site improvements.

4.4 SWELL/SETTLEMENT RELATED TO DEEP FILLS

The grading plans for the proposed redevelopment project were not ready at the time this report was published, and we have no information on the design thickness of proposed fill for this development. However, it is estimated that fills as deep or deeper than 10 feet will undergo settlement during placement and will continue to settle for a period of time following mass grading. When grading plans are available, we can provide an estimate for the upper and lower bound of settlement.

The potential for long-term settlement or heave as the fills eventually become wetted from irrigation and rainfall, which may occur over a long period of time (possibly several years following site grading), can be reduced by incorporating the fill placement and compaction recommendations provided in this report.

In our experience differential fill thicknesses in excess of 10 feet beneath building pads can adversely impact the long-term performance of residential structures. In our opinion, remedial grading should be performed to reduce differential fill thickness to no more than 10 feet across an individual building pad. When 40-scale grading plans are available, ENGEO should prepare a remedial grading plan which depicts areas where additional overexcavation is recommended to reduce differential fill thickness.

4.5 BEDROCK RIPABILITY AND SUITABILITY

If significant cuts are planned that could encounter bedrock, we anticipate that it will be possible to rip most of the bedrock material with heavy duty grading equipment. Localized lenses of massive hard rock are expected that may be difficult or impractical to rip and could result in oversize rock fragments in excess of 5 feet in diameter. It is likely that the oversize rock fragments will need to be processed with specialized equipment. Material that can not be broken down to less than 12 inches in diameter may need to be removed from the site or selectively placed at the bottom of deeper fills. Once the grading plans become available, the grading contractors may need to perform test excavations prior to preparing their bids to determine the most efficient means and methods of excavation.

Similarly, we anticipate that it will be possible to trench most of the bedrock using large excavator-type equipment. Localized lenses of massive hard rock are expected that will require laborious trenching efforts and may necessitate the use of excavators equipped with single-tooth ripping hooks or hydraulic hammers. Trenching of localized hard rock is likely to result in over-break of trench walls and oversized trench spoils. Depending on the phasing of construction, it may be preferable to overexcavate bedrock in areas of proposed trenching during grading when more effective and powerful equipment is available.

4.6 NATURALLY OCCURRING ASBESTOS

Serpentinite rock contains the fibrous mineral chrysotile, which is considered an asbestos mineral. Samples of bedrock collected from some of the exploratory test pits shown on Figure 3 were submitted to an analytical laboratory to check for the presence of naturally occurring asbestos derived from the weathering of serpentine found within the underlying Franciscan bedrock. MACS Lab, a state certified laboratory, checked for the asbestos content following the California Air Resources Board Test Method 435 (CARB 435), a 400-point count method. The test results indicated that the bedrock contained crysotile at concentrations exceeding 0.25% by weight as determined by the CARB 435. Test results are included in Appendix D

4.7 PERMEABILITY OF ON-SITE SOILS

From our exploration and laboratory analysis, we estimate that the hydraulic conductivity of the near surface on-site soils to be in the order of 2x 10^{-5} centimeters per second (cm/s) and 2x 10^{-4} cm/s. The United States Department of Agriculture has classified the majority of the site to be within group D soils, which means that the on-site soils have a very slow infiltration rate when thoroughly wet. Thus, it is expected that most of the rainfall is likely to run-off.

4.8 SEISMIC HAZARDS

Potential seismic hazards resulting from a nearby moderate to major earthquake can generally be classified as primary and secondary. The primary effect is ground rupture, also called surface faulting. The common secondary seismic hazards include ground shaking, and ground lurching. The following sections present a discussion of these hazards as they apply to the site. Based on topographic and lithologic data, the risk of regional subsidence or uplift, soil liquefaction, lateral spreading, landslides, tsunamis, flooding or seiches is considered low to negligible at the site.

4.8.1 Ground Rupture

Since there are no known active faults crossing the property and the site is not located within an Earthquake Fault Special Study Zone, it is our opinion that ground rupture is unlikely at the subject property.

4.8.2 Ground Shaking

An earthquake of moderate to high magnitude generated within the San Francisco Bay Region could cause considerable ground shaking at the site, similar to that which has occurred in the past. To mitigate the shaking effects, all structures should be designed using sound engineering judgment and the 2007 California Building Code (CBC) requirements, as a minimum. Seismic design provisions of current building codes generally prescribe minimum lateral forces, applied statically to the structure, combined with the gravity forces of dead-and-live loads. The code-prescribed lateral forces are generally considered to be substantially smaller than the comparable forces that would be associated with a major earthquake. Therefore, structures should be able to: (1) resist minor earthquakes without damage, (2) resist moderate earthquakes without structural damage but with some nonstructural damage, and (3) resist major earthquakes without collapse but with some structural as well as nonstructural damage. Conformance to the current building code recommendations does not constitute any kind of guarantee that significant structural damage would not occur in the event of a maximum magnitude earthquake; however, it is reasonable to expect that a well-designed and well-constructed structure will not collapse or cause loss of life in a major earthquake (SEAOC, 1996).

4.8.3 Ground Lurching

Ground lurching is a result of the rolling motion imparted to the ground surface during energy released by an earthquake. Such rolling motion can cause ground cracks to form in weaker soils.

The potential for the formation of these cracks is considered greater at contacts between deep alluvium and bedrock. Such an occurrence is possible at the site as in other locations in the Bay Area, but based on the site location, it is our opinion that the offset is expected to be very minor. Recommendations for foundation and pavement design provided in this report are intended to reduce the potential for adverse impacts from lurch cracking.

4.8.4 Liquefaction Potential

Soil liquefaction is a phenomenon under which saturated, cohesionless, loose soils experience a temporary loss of shear strength when subjected to the cyclic shear stresses caused by earthquake ground shaking. The site is located outside of the State of California Seismic Hazard Zones for areas that may be susceptible to liquefaction as shown on Figure 7. We did not encounter soil susceptible to liquefaction during our exploration. Therefore we consider the liquefaction hazard at the site to be low.

4.8.5 Seismically Induced Densification

Densification of loose sand above the groundwater level during earthquake shaking could cause settlement of the ground surface. In addition, densification of liquefiable soils, below the groundwater level, can cause detrimental settlement at the ground surface. As discussed above, loose layers of fill and soil susceptible to this type of densification were encountered on the site. However, with overexcavation of these soils during site development as discussed above, and as described later in this report, the potential for earthquake-induced densification can be lowered within the proposed development envelope.

4.8.6 Lateral Spreading

Lateral spreading is a failure within weaker soil material, which causes the soil mass to move toward a free face or down a gentle slope due to liquefaction. In general, the site has a low susceptibility to liquefaction; therefore, it is our opinion that lateral spreading is unlikely.

4.8.7 Seismically Induced Landsliding

As with most hillside developments, landslides and slope stability are important issues for the project. The northwest-southeast trending slope between Connecticut Street and Dakota Street shown on a State of California Seismic Hazard Zone map as an area that may be susceptible to seismically induced landsliding (Figure 8). The areas mapped as having the potential for seismically induced landsliding appear to consist of steeper existing slopes. Although seismically induced landsliding can be a significant hazard, it can generally be mitigated through proper slope design and grading procedures. Mitigation measures for this project will include re-grading of existing slopes and construction of proposed fill slopes with keyways, subdrainage and engineered fill. Grading in accordance with the recommendations provided in this report is intended to reduce the potential for seismically induced landsliding to low.

4.9 2007 CALIFORNIA BUILDING CODE (CBC) SEISMIC DESIGN PARAMETERS

Based on the subsurface soil conditions encountered and local seismic sources, the site may be characterized for design based on 2007 California Building Code using the following information.

TABLE 1
2007 CBC Seismic Parameters

Coefficient	Value
Mapped MCE Spectral Response Acceleration at Short Periods, S_S	1.50
Mapped MCE Spectral Response Acceleration at a Period of 1 second, S_1	0.691
Site Class	C
Long-period Transition Period, T_L	12 sec
MCE, 5% Damped, Spectral Response Acceleration at Short Periods Adjusted for Site Class Effects, S_{MS}	1.50
MCE, 5% Damped, Spectral Response Acceleration at a Period of 1 second Adjusted for Site Class Effects, S_{M1}	0.898
Design, 5% Damped, Spectral Response Acceleration at Short Periods, S_{DS}	1.0
Design, 5% Damped, Spectral Response Acceleration at a Period of 1 second, S_{D1}	0.599

4.10 CONCLUSIONS

It is our opinion, based on our review of earlier geotechnical studies on the site, the findings of our subsurface exploration and laboratory test results, that the proposed development is feasible from a geotechnical standpoint. The recommendations included in this report, along with other sound engineering practices, should be incorporated in the design and construction of the project.

5.0 RECOMMENDATIONS

5.1 GRADING

At the time of the publication of this report, the grading plans for the proposed development had not been prepared, but we understand that site grading will consist of cuts and fills to provide suitable building pads. When detailed grading plans are available, we can provide more specific corrective grading procedures for the site including a quantitative analysis of the grading scope. The location of keyways, subdrains, and subexcavation areas will be provided on the final grading plans. Buildings requiring special foundation design consideration will also be identified. At that time, we can also prepare a sequential analysis of the anticipated grading issues associated with the development.

All grading and project development plans should be coordinated with the Geotechnical Engineer to modify the plans to mitigate known soil and geologic hazards, as necessary. Notify ENGEO at least 48 hours prior to grading to coordinate our schedule with the grading contractor. Grading operations should meet the requirements of the Guide Contract Specifications included in the Appendix C and must be observed and tested by ENGEO's field representatives.

Ponding of stormwater, other than within engineered detention basins, should not be permitted at the site, particularly during work stoppage for rainy weather. Before the grading is halted by rain, positive slopes should be provided to carry the surface runoff to storm drainage structures in a controlled manner to prevent erosion damage.

5.2 DEMOLITION AND STRIPPING

Grading should begin with the removal of existing structures and associated foundation systems, buried pipes, septic tanks, leach fields, debris piles, designated fences, trees and associated root systems and other deleterious materials. Underground structures that will be abandoned or are expected to extend below proposed finished grades should be removed from the project site.

Existing fill, vegetation and soft or compressible soils in existing swales and other areas to be graded should be removed as necessary for project requirements. The depth of removal of these materials should be determined by the Geotechnical Engineer or qualified representative in the field at the time of grading.

Areas to receive fill and areas that serve as borrow for fill should be stripped of existing vegetation. Topsoil is estimated to be from 3 to 6 inches in thickness depending on location. Actual depths will be determined by the Geotechnical Engineer or qualified representative in the field during grading. Site strippings should be reserved for placement on graded slopes prior to installation of proposed erosion control measures. After placement on graded slopes, remaining strippings and organically contaminated soils which are not suitable for use as engineered fill may be used in approved open space areas or landscape areas. Any topsoil retained for future use in landscape areas should be approved by the Landscape Architect and stockpiled in areas where it will not interfere with mass grading operations.

Within the development areas, excavations resulting from demolition, clearing, and/or stripping which extend below final grades should be cleaned to firm undisturbed soil as determined by the Geotechnical Engineer's representative.

5.3 SOIL RECOMPACTION

In order to provide competent subgrade, we recommend that the fill and loose soils be removed, moisture conditioned, and compacted in accordance with the recommendations for engineered fill provided in this report. This recommendation assumes that the proposed grades will be similar to existing grades. The extent of the subexcavation under the proposed building footprints will be a function of the rigidity of the foundations as explained in the

Foundation Design section of this report. More site specific overexcavation recommendation will be provided once a grading plan has been designed.

5.4 SELECTION OF MATERIALS

With the exception of any organically contaminated materials (soil which contains more than 3 percent organics), the site soils are suitable for use as engineered fill. The Geotechnical Engineer should be informed when import materials are planned for the site. Import materials should be submitted and approved by the Geotechnical Engineer prior to delivery at the site and should conform to the requirements provided in Section 2.02B of Part I of the Guide Contract Specifications.

5.5 GRADED SLOPES

From our test results and previous experience on other hillside developments, the following slope gradient guidelines are provided that may generally be applied for the design of the engineered slopes:

Slope Configuration	Recommended Maximum Gradient (horizontal:vertical)
Cut slopes up to 10 feet high	2:1
Cut slopes between 10 and 15 feet	2½:1
Cut slopes greater than 15 feet high	3:1
Fill slopes up to 20 feet high	2:1
Fill slopes between 20 and 30 feet high	2½:1
Fill slopes greater than 30 feet high	3:1

Cut slopes that exceed the recommended gradient guidelines need to be reconstructed as fill slopes. Fill slopes that exceed the recommended gradient guidelines need to be constructed with geogrid reinforcement.

We recommend placing topsoil strippings over all open space cut and fill slopes immediately following grading and prior to the installation of erosion control measures. Topsoil placed on cut and fill slopes should be no more than 6 inches thick. In our opinion, placing the site strippings on graded slopes reduces rainfall infiltration to natural levels, more actively promotes re-vegetation, enhances local slope stability and provides a more natural slope appearance.

All cut slopes should be examined by the Project Engineering Geologist during slope grading for adverse bedding, seepage, or bedrock conditions that may affect slope stability. In the event that adverse geologic conditions are detected during grading of the cut slopes, overexcavation and reconstruction of these slopes may be necessary. Track rolling to compact the face of fill slopes is not sufficient. Fill slopes should be overbuilt at least 2 feet and cut back to design grades.

5.6 FILL PLACEMENT

After stripping or subexcavation of the on-site loose soils, the firm undisturbed surface should be scarified to a depth of 12 inches, moisture conditioned and recompacted to provide adequate bonding with the initial lift of fill. All fills should be placed in thin lifts. The lift thickness should not exceed 8 inches or the depth of penetration of the compaction equipment used, whichever is less. Track rolling to compact faces of slopes is usually not sufficient; typically, slopes should be overfilled a minimum of 2 feet and cut back to design grades.

5.7 MONITORING AND TESTING

The Geotechnical Engineer's representative should be present during all phases of the grading operations to provide as-needed testing and observation services. The following compaction recommendations should be used for the placement and compaction of engineered fills:

1. Moderately to highly expansive soil and bedrock material (P.I greater than 12) should be moisture conditioned to at least 3 percentage points above the optimum moisture content and compacted to a minimum relative compaction of 90 percent.

2. Non- to low-expansive soil and bedrock materials (P.I. less than or equal to 12) should be moisture conditioned to above optimum moisture content and compacted to a relative compaction of not less than 90 percent.

3. Engineered fill used to construct toe buttresses should be moisture conditioned to at least optimum moisture content and compacted to a relative compaction of not less than 95 percent.

4. All fill placed more than 25 feet below finished grading should be moisture conditioned to at least optimum moisture content and be compacted to a relative compaction of not less than 95 percent

Relative compaction refers to in-place dry density of the fill material expressed as a percentage of the maximum dry density as determined by ASTM D-1557-91. Optimum moisture is the moisture content corresponding to the maximum dry density.

5.8 KEYWAYS

After stripping, mass grading should begin with construction of keyways and subdrains. Fills should be adequately keyed into firm natural materials. Anticipated keyway sizes and locations should be determined by the project Geotechnical Engineer after the final 40-scale grading plans become available. Typical minimum keyway sizes and subdrains are shown on Figures 9 and 10. The actual depth of the keyways will be determined in the field by the Geotechnical Engineer during grading. Fills placed on slopes above keyways should be benched into firm competent soil or bedrock and drained as appropriate. Unless otherwise recommended by the Geotechnical Engineer, benches should be constructed at vertical intervals of not less than 5 feet.

5.9 CONSTRUCTION OF SUBSURFACE DRAINS

Subsurface drainage systems should be installed in all keyways, swales or natural drainage areas. Swales and drainage courses should be overexcavated to a firm base, as determined by the Geotechnical Engineer during grading. A trench subdrain should then be installed through the center of the subexcavation as shown in Figure 10. The approximate location of the recommended subdrains should be shown on the final 40-scale grading plans prior to the beginning of the site work.

Subdrains should also be added where wet conditions are encountered during excavations. Subdrain systems should consist of a minimum 6-inch-diameter perforated pipe encased in at least 18 inches of Caltrans Class 2 permeable material or coarse drain rock wrapped in geotextile filter fabric. For selected keyway and bench subdrains, pre-manufactured synthetic edge drains may be substituted for the perforated pipe and permeable material. Typical subdrain details are shown in Figure 10. The subdrain pipe should meet the requirements contained in Section 2.05, Part I of the Guide Contract Specifications. Discharge from the subdrains will generally be low but in some instances may be continuous. Subdrains should outlet into open drainages or the proposed storm drain system and their locations should be documented by the Project Civil Engineer for future maintenance.

Not all sources of seepage have been uncovered during our field work because of the intermittent nature of some of these conditions and their dependence on long-term climatic conditions. Furthermore, new sources of seepage may be created by a combination of changed topography, man-made irrigation patterns and potential utility leakage. Since uncontrolled water movements are one of the major causes of detrimental soil movements, it is of utmost importance that the Geotechnical Engineer be advised of any seepage conditions encountered during or after grading so that remedial action may be initiated, if necessary. Subdrains and cleanouts should be surveyed in the field and their locations recorded so that they may be located in the future.

5.10 DIFFERENTIAL FILLS

Remedial grading should be performed to reduce differential fill thickness to no more than 10 feet across an individual building pad. Remedial grading plans will be provided once the proposed grading plans have been finalized.

5.11 CUT-FILL TRANSITION BUILDING PADS AND CUT PADS

Some building pads in this project will likely be entirely in cut or traversed by a cut/fill transition. It can be anticipated that significant variations in material properties may occur in areas of cut or cut/fill transition if not mitigated during site grading. It is our opinion that there is a potential for significant differential in swell characteristics or settlement across cut areas and cut/fill transitions. Such situations can be detrimental to building performance. We recommend that cut lots/pads be overexcavated 12 inches and recompacted to provide a uniform thickness of engineered fill within the entire foundation area. For cut/fill transition lots, the cut portion of the lots should be overexcavated 24 inches (Figure 11). In each case, the base of the subexcavated area should be scarified by cross ripping and then constructed to pad grade with engineered fill.

5.12 FOUNDATION DESIGN

The major considerations in foundation design for structures proposed for this project are the effects of potential differential movement of on-site soils as a result of dynamic densification, of their shrink-swell characteristics and the distance of the proposed structure from the top of the slope. The effects of potential foundation movement can be reduced by the choice of a proper foundation system. In order to reduce the effects of potential differential movement, the foundations should be sufficiently stiff to move as rigid units. This section provides recommendations for appropriate foundation types. Final foundation plans should be submitted to the project Geotechnical Engineer for review prior to submittal to the appropriate agency. For planning purposes, we have prepared the following table which identifies the appropriate foundation system for a given site condition. Specific design parameters for the recommended foundations are discussed below.

FOUNDATION SYSTEMS

Foundation type	Depth of subexcavation of loose material*	Greater than 10 feet back from the top of the slope	Less than 10 feet back from the top of the slope	Greater than 10 feet differential fill	Less than 10 feet differential fill
Conventionally Reinforced Structural Mat Foundation	Up to 24-inches**	X			X
Stiffened Ribbed Mat Foundation	Up to 24-inches**	X			X
Post Tensioned Slab Foundation	Up to 24-inches**	X			X
Spread Footings Foundation	Up to 60-inches***	X			X
Drilled Piers with Raised Floor Foundation	N/A		X	X	

* The depth of subexcavation varies per location. The actual depth of subexcavation will be determined in the field by the Geotechnical Engineer.
**Under the entire building footprint and extending at least 5 feet beyond the limits of the new proposed building pads.
*** Under the footprint of the footings.

5.13 CONVENTIONALLY REINFORCED STRUCTURAL MAT FOUNDATION

Buildings located on level pads at least 10 feet from the top of slope with differential fill thickness less than 10 feet can be supported utilizing a mat foundation system. Conventionally reinforced structural mats should be designed for a 5-foot edge-cantilever distance and a 15-foot unsupported interior-span distance. These structural mats should have a minimum thickness of 10 inches and should be thickened to 12 inches at the perimeter.

Mats should be reinforced with top and bottom steel as determined by the Structural Engineer to provide structural continuity and permit spanning of local irregularities. Structural reinforced mats should be designed to accommodate a maximum differential movement of 1/600 of the effective span without experiencing structural distress to the slabs or excessive deflections in the framing and wall finishes. Structural mats should be designed for an allowable uniform soil pressure of 1,500 pounds per square foot (psf). The minimum backfill height of soil against the mat at the perimeter should be 6 inches. The resistance to lateral loads should be computed using a base friction factor of 0.35 acting between the bottom of the mat and subgrade.

5.14 STIFFENED RIBBED MAT FOUNDATION

Buildings may be supported utilizing a ribbed mat foundation system stiffened with continuous strip footings. The strip footings should have a minimum width of 12 inches and extend at least 24 inches below the top of the slab. The continuous footings should be designed by a Structural Engineer to be reinforced with top and bottom steel to provide structural continuity and to permit spanning of local irregularities. Footings should be designed to form a rigid grid and be reinforced to accommodate a differential movement of ½ inch over 20 feet. In addition, the Structural Engineer should consider designing the footing reinforcement to limit excessive deflections in the framing and wall finishes.

Continuous footings should be designed for an allowable bearing pressure no greater than 2,500 psf; this value may be increased by one-third for wind and seismic loads. A passive resistance pressure of 250 pounds per cubic foot (pcf), equivalent fluid weight, may be used for design if the area in front of the footing is level for at least 8 feet. The upper 1 foot of footing embedment should be neglected for passive resistance pressure. For foundations located within 8 feet from the edge of slopes (measured horizontally) passive resistance should be neglected. A base friction factor of 0.35 may be used in the design.

Footings founded in expansive soils may be subjected to detrimental uplift forces along the sides of the footings. To help reduce the potential for uplift pressures in expansive soils, we recommend that all perimeter footings achieve bearing support a minimum of 24 inches below the lowest adjacent grade and that any expansive soil in the upper 12 inches of the building pads be replaced with low to non-expansive soil with a Plasticity Index of 12 or less. Footing excavations should be kept moist prior to placing foundation concrete.

5.15 POST-TENSIONED MAT FOUNDATION DESIGN

Post-tensioned slab foundations are suitable to provide support of the proposed buildings that are located at least 10 feet from the top of slopes. Post-tensioned slabs should be designed according to the method recommended in the Design and Construction of Post-Tensioned Slabs-on-Ground, Third Edition (PTI, 2004) and the 2007 California Building Code. Soil design criteria for the post-tensioned slab foundations are as follows:

Post-tensioned mat design parameters:

Center Lift Condition:	Edge Moisture Variation Distance, e_m= 9 feet Differential Soil Movement, y_m = 0.2 inch
Edge Lift Condition:	Edge Moisture Variation Distance, e_m = 5.0 feet Differential Soil Movement, y_m= 0.6 inch

Post-tensioned slabs should be designed for an average allowable soil pressure of 1,500 pounds per square foot (psf). These values may be increased by one-third when considering total loads, including wind or seismic loads. We recommend a minimum concrete thickness of 10 inches. The actual thickness of the slab should be determined by the project Structural Engineer. It should be noted that the design criteria provided is based on assumption that the foundation will be founded on non-expansive material. Plasticity Indices testing is recommended to be obtained on the near-surface material once final grading has been completed.

5.16 SPREAD FOOTING FOUNDATIONS

Buildings located on level building pads at least 10 feet from the top of slope can be supported utilizing spread footing foundations (isolated or continuous) assuming that the subgrade has been prepared as recommended above. We recommend using stiffened continuous strip footings. Where zero-lot-line pads with different elevations exist, the lower residential unit should be designed to resist the surcharge loads from the upper residential unit, or the footings of the upper unit adjacent to the lower unit should be constructed at the same elevation of the footings of the lower unit to prevent the surcharge loads from the upper unit being transferred to the lower unit. If moderately expansive clays are encountered at the bottom of the foundation excavations, these soils should be removed and replaced with low to non-expansive material (PI less than 12).

The spread footings should be a minimum of 12 inches wide and should be founded in either properly compacted fill, or directly on firm natural soil deposits. Footing trenches should be cleared of loose soil prior to concrete placement. It is important that footing trenches not be allowed to desiccate prior to placing concrete.

Preliminary geotechnical design criteria for use in footing sizing are as follows:

Minimum depth of footing embedment:	18 inches below lowest adjacent grade.
Maximum allowable footing pressure:	2,500 psf dead plus live loads. Increase by one-third when considering total loads including wind or seismic loads.

Resistance to lateral loads can be obtained from a combination of passive earth pressures against the face of the foundation and soil friction along the base of the foundation. To resist lateral loads, a passive pressure corresponding to an equivalent fluid weighing 250 pounds per cubic foot (pcf) and a base friction factor of 0.35 times net vertical dead load should be used. Lateral resisting pressures in the upper one foot should be neglected if the footings are not confined by slab or pavement.

5.17 DRILLED PIERS WITH RAISED FLOOR FOUNDATIONS

Buildings, including those that are located within 10 feet of the top of slopes and/or with differential fill thickness greater than 10 feet, can be supported on drilled piers with raised floors. The piers should be interconnected by grade beams and used in conjunction with raised floors. The construction of deeper piers with a wider spacing and stiffer grade beams is preferred. We also recommend extending the piers into firm, natural materials as determined by ENGEO from the boring data and also from pier drilling during construction.

Pier design and construction criteria recommended are as follows:

Pier diameter:	Minimum of 16 inches or 5 percent of pier length, whichever is greater.
Pier depth:	Not less than 15 feet and at least 5 feet into competent material whichever is greater.
Pier load capacity:	The allowable pier capacity may be determined using a side friction of 500 psf, neglecting the upper 2 feet of pier embedment.
Pier uplift capacity:	The allowable pier uplift capacity may be determined using a side friction of 350 psf plus the weight of the pier.

The pier spacing should be determined from the load-bearing capacity of the piers; in no case should it be less than three pier diameters on centers. Well-reinforced grade beams should interconnect the foundation piers supporting bearing walls. Isolated piers may be used to support floor loads and isolated point loads where located at least 15 feet from the top of a slope; however, the number of isolated piers should be kept to a minimum.

Piers located on or within 15 feet of the top of slope should be designed to resist lateral creep loads using a uniform pressure of 400 psf acting on a pier diameter against the upper 5 feet of the pier. Lateral loads may be resisted by passive pressures generated below a depth of 5 feet. For passive resistance, an equivalent fluid weight of 250 pounds per cubic foot (pcf) acting on 2 times the diameter may be used for the portions below a depth of 5 feet.

The Structural Engineer should design the pier-and-grade-beam reinforcement. As a minimum, at least two No. 5 rebar should extend the full length of each pier; at least four No. 5 rebar should be used for piers located on or within 15 feet of the top of slope.

Pier hole drilling should be done under the observation of the Geotechnical Engineer or his qualified representative to confirm that the above recommendations are being complied with and so that alternative action may be implemented when subsurface conditions vary from those encountered in the borings. If refusal to drilling is encountered, the Geotechnical Engineer, in consultation with the Structural Engineer, should determine what measures, if any, need to be taken. In order to minimize potential future pier settlements, all loose soil should be removed from the bottom of pier holes prior to placing concrete. Pier holes should not be allowed to desiccate before placing concrete. Depressions at the top of the piers resulting from drilling operations or from any other cause should be backfilled to prevent ponding. Concrete collars occurring at the top of the piers as a result of placing should be removed to prevent unnecessary uplift forces against the piers.

We recommend that the grade beams be underlain by a 3-inch minimum void space. This may be achieved by the use of degradable material such as Surevoid or equivalent material at least 3 inches thick provided between the bottom of the grade beams and the ground. As an alternative to the recommended void space beneath grade beams, the grade beams may rest upon grade provided they are designed to resist an upward swell pressure of 1,500 pounds per square foot. All grade beams should be reinforced to maximize their moment capacity. The grade beam reinforcement will be dependent on the pier spacing and the structural loads to be supported, but in no case should less than four No. 5 rebars be used, two in the top and two in the bottom of the beam.

Foundation drainage should provide rapid removal of any water that may otherwise tend to flow under the house, as discussed in the subsequent sections of this report. In addition, it is recommended that at least 12 inches of soil be placed and compacted on the outside of the grade beam and sloped away from the foundation at right angles to the grade beam to provide for rapid removal of surface water runoff.

5.18 STRUCTURAL MAT/POST-TENSION SLAB SUBGRADE PREPARATION

The subgrade material under slabs on grade, structural mats or post-tensioned slabs should be uniform and properly moisturized. The upper 12 inches of subgrade should be moisture conditioned to at least 3 percentage points above optimum moisture content. The subgrade should be thoroughly soaked prior to placing the concrete and should not be allowed to dry prior to concrete placement. The Structural Engineer should be consulted on the advisability of using a 2-inch-thick sand cushion (Section 2.03, Part I of Guide Contract Specifications) under slabs for concrete curing purposes. Where floor coverings are anticipated, we recommend that the concrete be underlain by a tough, water vapor retarder at least 10 mils thick (Section 2.05D, Part I of Guide Contract Specifications) to minimize moisture condensation under the floor coverings. Foundation subgrade soils should be protected from seepage by providing impermeable plugs within utility trenches as described in the "Utilities" section of this report.

5.19 SECONDARY SLABS-ON-GRADE

This section provides guidelines for secondary slabs such as porch slabs, exterior patio slabs, walkways, driveways and steps. It also includes garage slabs for residences utilizing raised floors for living spaces. Secondary slabs-on-grade should be constructed structurally independent of the foundation system. This allows slab movement to occur with a minimum of foundation distress. Where slab-on-grade construction is anticipated, care must be exercised in attaining a near-saturation condition of the subgrade soil before concrete placement.

Slabs-on-grade should be designed specifically for their intended use and loading requirements. Some of the site soils have a moderate to high expansion potential; therefore, cracking of conventional slabs should be expected. As a minimum requirement, slabs-on-grade should be reinforced for control of cracking. Slab reinforcement should be designed by the Structural Engineer. In our experience, welded wire mesh is generally not sufficient to control slab cracking. Therefore, we recommend the Structural Engineer consider using a minimum of No. 3 bars for design of the slab reinforcement.

Slabs-on-grade should have a minimum thickness of 4 inches with a thickened edge extending at least 6 inches into compacted soil to minimize water infiltration. A 4-inch-thick layer of clean crushed rock or gravel should be placed under sidewalk and driveway slabs. As an alternative to providing a 6-inch-thick edge, a minimum 5½-inch-thick slab could be placed over 4 inches of clean crushed rock or gravel.

5.20 FOUNDATION DRAINAGE

We recommend that a subsurface drain be provided around the perimeter of the structures that have raised floors and crawl spaces to help protect against subsurface seepage under the foundation. The subdrainage trench should be at least 12 inches wide and at least 6 inches below the bottom of the footing or perimeter grade beam as shown on Figure 12. It should contain a perforated pipe (with perforations down) surrounded with Class 2 permeable material. All trenches and pipes should have a minimum slope of 1 percent.

The closed roof downspout collector pipe (described below) and the perimeter subdrain can be constructed in a single trench, if desired; however, the closed collector pipe must be placed above the perimeter subdrain pipe, and in no case may the subdrain pipe be connected to the closed drain pipe system (Figure 12).

5.21 SURFACE DRAINAGE

The project lots must be positively graded at all times to provide for rapid removal of surface water runoff away from the foundation systems and to prevent ponding of water under floors or seepage toward the foundation systems at any time during or after construction. Ponded water will cause undesirable soil swell and loss of strength. Care should be exercised to provide that landscape mounds or walkways will not interfere with this requirement. Area drains may be needed to comply with these requirements in some instances.

Ponding of stormwater must not be permitted on the lots during prolonged periods of inclement weather. As a minimum requirement, unpaved finished grades should have slopes of at least 3 percent and hardscaped areas should have slopes of at least 1 percent within 5 feet of the exterior walls and at right angles to them to allow surface water to drain positively away from the structure. All surface water should be collected and discharged to the street, sustainable landscape features or into the storm drain system in accordance with the City of San Francisco requirements. Landscape mounds must not interfere with this requirement.

All roof stormwater should be collected and directed to downspouts. Stormwater from roof downspouts should be carried away in closed conduits to collection points designed by the Civil Engineer.

5.22 RETAINING WALLS

Unrestrained drained retaining walls less than 10 feet in vertical height may be designed for active lateral equivalent fluid pressures. Foundation retaining walls for house structures should be supported on similar foundations used for the individual structures as discussed above. Since these walls are anticipated to be restrained, we recommend the use of at-rest earth pressures in their design. Other retaining walls not adjoining house structures may be designed for active earth pressures since these walls are anticipated to be free to rotate at the top of the walls.

Retaining walls should be designed to withstand the following equivalent fluid pressures, which do not include increases due to surcharge or hydrostatic pressures.

Backfill Slope Condition	Active Pressure (pcf)	At-Rest Pressure (pounds per cubic foot)
Level	50	75
4:1	55	80
3:1	60	90
2:1	70	100

Passive pressures acting on foundations may be assumed as 250 (pcf) provided that the area in front of the retaining wall is level for a distance of at least 10 feet or three times the depth of foundation, whichever is greater. When on level ground, unless the surface in front of the wall is confined by a slab or pavement, the upper one foot of soil should be neglected when calculating passive resistance.

The friction factor for sliding resistance may be assumed as 0.35. It is recommended that retaining wall footings be designed using an allowable bearing pressure of 2,500 (psf) in firm native materials or fill. Appropriate safety factors against overturning and sliding should be incorporated into the design calculations.

All retaining walls should be provided with drainage facilities to prevent the build-up of hydrostatic pressures behind them. In addition, foundation walls should be waterproofed. Wall drainage may be provided using prefabricated synthetic wall drain panels or Class 2 permeable material (Appendix D, Part I - Guide Contract Specifications, Section 2.05B), or free-draining gravel surrounded by synthetic filter fabric. The width of the gravel type drain blanket should be at least 12 inches. The drain blanket should extend from the bottom of wall to about one foot below the finished top grades. The upper 1 foot of wall backfill should consist of on-site clayey soil. Drainage should be collected by perforated pipes and directed to an outlet approved by the Civil Engineer. Synthetic filter fabric should meet the minimum requirement provided in the Guide Contract Specifications.

For a mechanically stabilized earth wall (such as Keystone), the following soil criteria should be incorporated in the design:

	Cohesion (c') (pcf)	Friction Angle (∅') (degrees)	Unit Weight (γ) (pcf)
Reinforced Fill	0	28	125
Retained Soil	0	28	125
Foundation Soil	0	28	130

Appropriate minimum safety factors should also be incorporated into the design calculations as listed below:

External Stability:

	Safety Factor
Sliding	1.5
Bearing Capacity	2.0
Overturning	2.0

Internal Stability:

	Safety Factor
Pull-out Resistance	1.5

All backfill should be placed in accordance with recommendations provided above for engineered fill. Light equipment should be used during backfill compaction to minimize possible overstressing of the walls.

5.23 SUSTAINABLE LANDSCAPE FEATURES

It is likely that the Project Landscape Architect will require sustainable landscape features such as continuous vegetated swales, bioretention strips, and rainwater receiving areas throughout the proposed development for treatment and peak runoff attenuation Best Management Practices (BMPs).

In general, underdrains associated with the proposed landscape features should not discharge water to perforated subdrains associated with foundations, retaining walls, keyways and swale overexcavations, but they may connect to the solid unperforated outfall lines of these subdrain systems. Water collected from subdrains associated with foundations, retaining walls, keyways, and swell overexcavations may discharge to the underdrains of the proposed landscape features

It is our understanding that sustainable landscape features may be constructed adjacent to building structures. In general, the proposed landscape features should be at least 5 feet away from building foundations. If the proposed landscape features are less than 5 feet away from building foundations as a result of space constrains, they should be lined with an impermeable liner approved by the Geotechnical Engineer. The layout, gradient, shape, and size of the proposed landscape features should be reviewed and approved by the Geotechnical Engineer.

From the geotechnical standpoint, it is very important that ponding water is not allowed adjacent to building structures and the proposed landscape features will be constructed at a gradient that discharges the water away from the building foundations. Stormwater from building roofs should be collected on the downhill side of building structures before it is diverted to proposed landscape features.

Below grade podium walls should be waterproofed, and all construction joints between the footings and foundation walls should have a water stop. In addition, water collection systems such as a strip drain or equivalent should be installed behind all below grade podium walls to avoid the build up of hydrostatic pressure. In lieu of water collection systems behind walls, the walls can be designed to resist hydrostatic pressures.

5.24 REQUIREMENTS FOR LANDSCAPING IRRIGATION

The geotechnical foundation design parameters contained in this report have considered the swelling potential of some of the site soils. However, it is important to recognize that swell in excess of that anticipated is possible under adverse drainage and irrigation conditions. Therefore, planted areas should be avoided immediately adjacent to the buildings. If planting adjacent to a residence is desired, the use of watertight planter boxes with controlled discharge or the use of plants that require very little moisture is recommended.

Sprinkler systems should not be installed where they may cause ponding or saturation of foundation soils within 3 feet from walls. Such ponding or saturation could result in undesirable soil swell, loss of compaction and consequent foundation and slab movements.

Irrigation of landscaped areas should be strictly limited to that necessary to sustain vegetation. Excessive irrigation could result in saturating, weakening, and possible swelling of foundation soils. The Landscape Architect and prospective owners should be informed of the surface drainage requirements included in this report.

5.25 EROSION CONTROL

In addition to vegetated cover, viable erosion mitigation measures may include concrete or asphalt-lined drainage facilities and slopes graded to 3:1 (horizontal:vertical) or steeper. These measures are typically used on slopes with heights greater than 30 feet. The purpose of the drainage facilities is to intercept and divert the surface water runoff from the slopes, and reduce runoff velocities, water infiltration and sloughing or erosion of the slope surfaces.

Erosion of graded slopes can be mitigated by hydroseeding, landscaping or placement of topsoil materials prior to the winter rains following rough grading. All landscaped slopes should be maintained in a vegetated state after project completion with drought tolerant vegetation requiring drip irrigation.

The top of fill or cut slopes should be graded in such a way as to prevent water from flowing freely down the slopes. Due to the nature of the bedrock, slopes may experience severe erosion when grading is halted by heavy rain; therefore, before work is stopped, a positive gradient away from the slopes should be provided to carry the surface runoff away from the slopes to areas where erosion can be controlled. It is vital that no completed slope be left standing through a winter season without erosion control measures having been provided.

5.26 PRELIMINARY PAVEMENT DESIGN

Based on the Standards and Specifications of the City and County of San Francisco the pavement section for roads should consist of a 2-inch-thick layer of asphalt-concrete on an 8-inch layer of Portland Cement Concrete. The pavement section for private roads, where traffic loads will be less, may consist of a 2-inch-thick layer of asphalt-concrete on a 6-inch layer of Portland Cement Concrete with the City's approval. Pavement construction and all materials should comply with the requirements of the Standard Specifications of the State of California Division of Highways, County requirements and the following minimum requirements.

- All pavement subgrades should be scarified to a depth of 12 inches below finished subgrade elevation, moisture conditioned to 2 percentage points above optimum, and compacted to at least 95 percent relative compaction and in accordance with City and County of San Francisco requirements.
- Subgrade soils should be in a stable, non-pumping condition at the time road base materials are placed.
- Adequate provisions must be made such that the subgrade soils are not allowed to become saturated.
- Asphalt paving materials should meet current County and City of San Francisco specifications for asphalt concrete.

5.26.1 Concrete Pervious Pavements

If the design team agrees that concrete pervious pavements is a good option, care should be taken on conditioning the subgrade soils and selecting the appropriate thickness of the concrete pavement. Concrete pervious pavement should be placed on two inches of sand overlying the aggregate base material. The aggregate base material should be based on ASTM 57. Based on our review of previous studies, our field exploration and laboratory testing, we estimate that the required thickness of aggregate base to be:

TI	Permeable Aggregate Base Thickness (inches)
6	8
7	10

In areas where clayey conditions are found a layer of geotextile, such as Mirafi 500X, should be placed between the subgrade and aggregate base. The geotextile should be turned up against the sides of the excavation prior to placing the aggregate base. For the same reason, a subdrain system should be installed beneath the aggregate base to collect the water and directed to the stormwater system.

5.27 UTILITIES

It is recommended that all utility trench backfill be done under the observation of a Geotechnical Engineer. Pipe zone backfill (i.e. material beneath and immediately surrounding the pipe) may consist of a well-graded import or native material less than ¾-inch in maximum dimension. Trench zone backfill (i.e. material placed between the pipe zone backfill and the ground surface) may consist of native soil compacted in accordance with recommendations for engineered fill.

Where import material is used for pipe zone backfill, we recommend that it consist of fine- to medium-grained sand or a well-graded mixture of sand and gravel and that this material not be used within 2 feet of finish grades. In general, uniformly graded gravel should not be used for pipe or trench zone backfill due to the potential for migration of: (1) soil into the relatively large void spaces present in this type of material; and (2) water along trenches backfilled with this type of material. All utility trenches entering buildings or passing below curbs must be provided with an impervious seal consisting of native materials or concrete where the trenches pass under building perimeters or curb. The impervious plug should extend at least 3 feet to either side of the crossing. This is to prevent surface water percolation into the sands under foundations and pavements where such water would remain trapped in a perched condition, allowing clays to develop their full expansion potential.

Utility trenches should not be located upslope of any foundation area unless the placement, depth and backfill material to be used are reviewed by the Geotechnical Engineer. Care should be exercised where utility trenches are located beside foundation areas. Utility trenches constructed parallel to foundations should be located entirely above a plane extending down from the lower edge of the footing at an angle of 45 degrees. Utility companies and Landscape Architects should be made aware of this information.

It is the responsibility of the contractor to provide a safe and stable trench side-wall condition. The contractor should follow the trench safety requirements of CAL-OSHA and the City of San Francisco.

Utility trenches in areas to be paved should be backfilled to the specifications provided in this report for engineered fill and in accordance with City of San Francisco requirements; however, compaction of trench backfill by jetting shall not be allowed at this site.

6.0 LIMITATIONS AND UNIFORMITY OF CONDITIONS

This report is issued with the understanding that it is the responsibility of the owner to transmit the information and recommendations of this report to developers, owners, buyers, architects, engineers, and designers for the project so that the necessary steps can be taken by the contractors and subcontractors to carry out such recommendations in the field. The conclusions and recommendations contained in this report are solely professional opinions.

The professional staff of ENGEO Incorporated strives to perform its services in a proper and professional manner with reasonable care and competence but is not infallible. There are risks of earth movement and property damages inherent in land development. We are unable to eliminate all risks or provide insurance; therefore, we are unable to guarantee or warrant the results of our services.

This report is based upon field and other conditions discovered at the time of preparation of ENGEO's report. This document must not be subject to unauthorized reuse that is, reusing without written authorization of ENGEO. Such authorization is essential because it requires ENGEO to evaluate the document's applicability given new circumstances, not the least of which is passage of time. Actual field or other conditions will necessitate clarifications, adjustments, modifications or other changes to ENGEO's documents. Therefore, ENGEO must be engaged to prepare the necessary clarifications, adjustments, modifications or other changes before construction activities commence or further activity proceeds. If ENGEO's scope of services does not include on-study area construction observation, or if other persons or entities are retained to provide such services, ENGEO cannot be held responsible for any or all claims arising from or resulting from the performance of such services by other persons or entities, and from any or all claims arising from or resulting from clarifications, adjustments, modifications, discrepancies or other changes necessary to reflect changed field or other conditions.

SELECTED REFERENCES

Blake, T. F., 2000, EQFAULT, A Computer Program for the Deterministic Prediction of Peak Horizontal Acceleration from Digitized California Faults.

Schlocker, J., Bonilla, M.G. and Radbruch, D.H. 1958, Geology of the San Francisco North Quadrangle, San Francisco Bay Area, California: a Digital Database, U.S. Geological Misc. Geologic Investigations, Map I-272.

Boore et al., 1997, in Blake, T.F., 1996, EQSEARCH computer program, referenced as personal communication to Blake, p106.

California Department of Transportation, 1992, Highway Design Manual.

California Geological Survey (CGS), 1997, Guidelines for Evaluating and Mitigating Seismic Hazards in California, Special Publication 117, March.

Frankel, Arthur D. et al. Documentation for the 2002 Update of the National Seismic Hazard Maps, Open-file Report 02-420.

International Code Council, 2007 California Building Code.

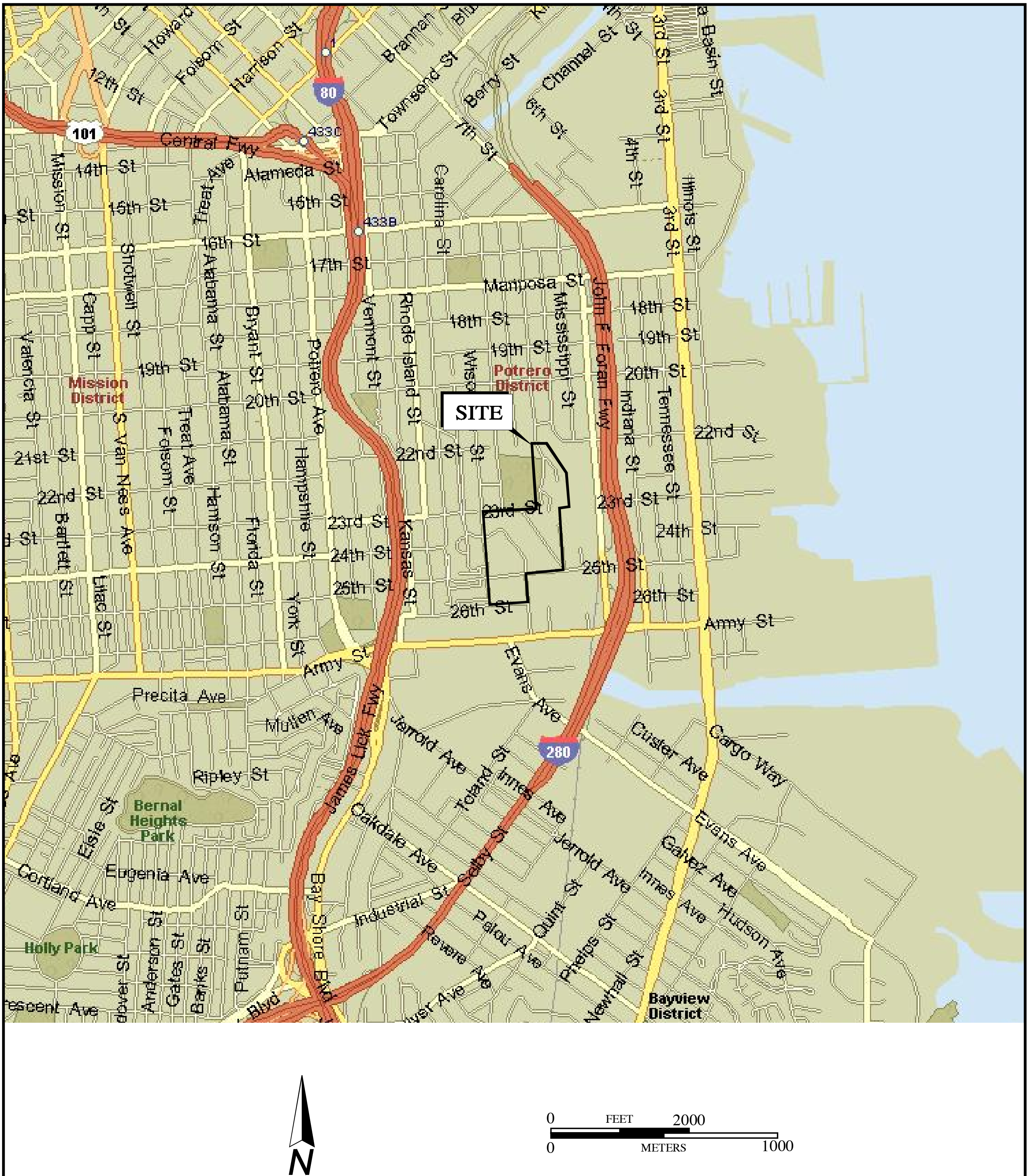
Ishihara, K., 1985, Stability of Natural Deposits During Earthquakes: Proceedings Eleventh International Conference on Soil Mechanics and Foundation Engineering, San Francisco.

Ishihara, K., 1985, Stability of Natural Deposits During Earthquakes: Proceedings of the Eleventh International Conference on Soil Mechanics and Foundation Engineering.

SEAOC, 1996, Recommended Lateral Force Requirements and Tentative Commentary.

WGCEP, 2007; Earthquake Probabilities in San Francisco Bay Region 2002-2031; U.S. Geological Survey; Open-File Report 03-214.

LIST OF FIGURES

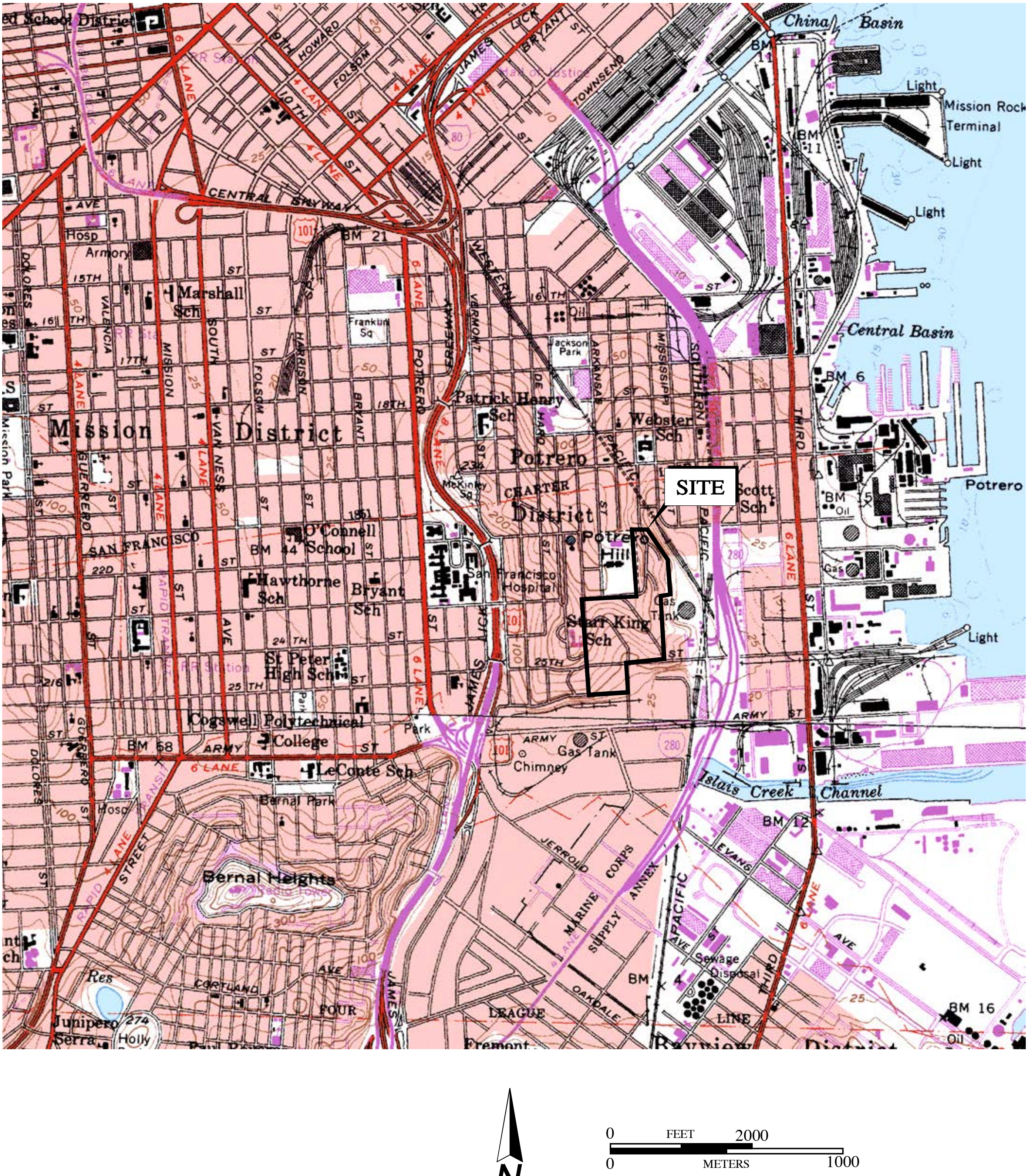


BASE MAP SOURCE: MS STREETS AND TRIPS

ENGEO Expect Excellence	VICINITY MAP POTRERO ANNEX AND TERRACE SAN FRANCISCO, CALIFORNIA	PROJECT NO.: 8683.000.000 DATE: JULY 2009 DRAWN BY: SRP CHECKED BY: BF	FIGURE NO. 1

G:\Drafting\DRAFTING2_Dwg\8683\000\GEX\8683000000-GEX-1-VicinityMap-0709.dwg 2-16-10 02:54:55 PM dborde

ORIGINAL FIGURE PRINTED IN COLOR



BASE MAP SOURCE: U.S.G.S.

ENGEO
Expect Excellence

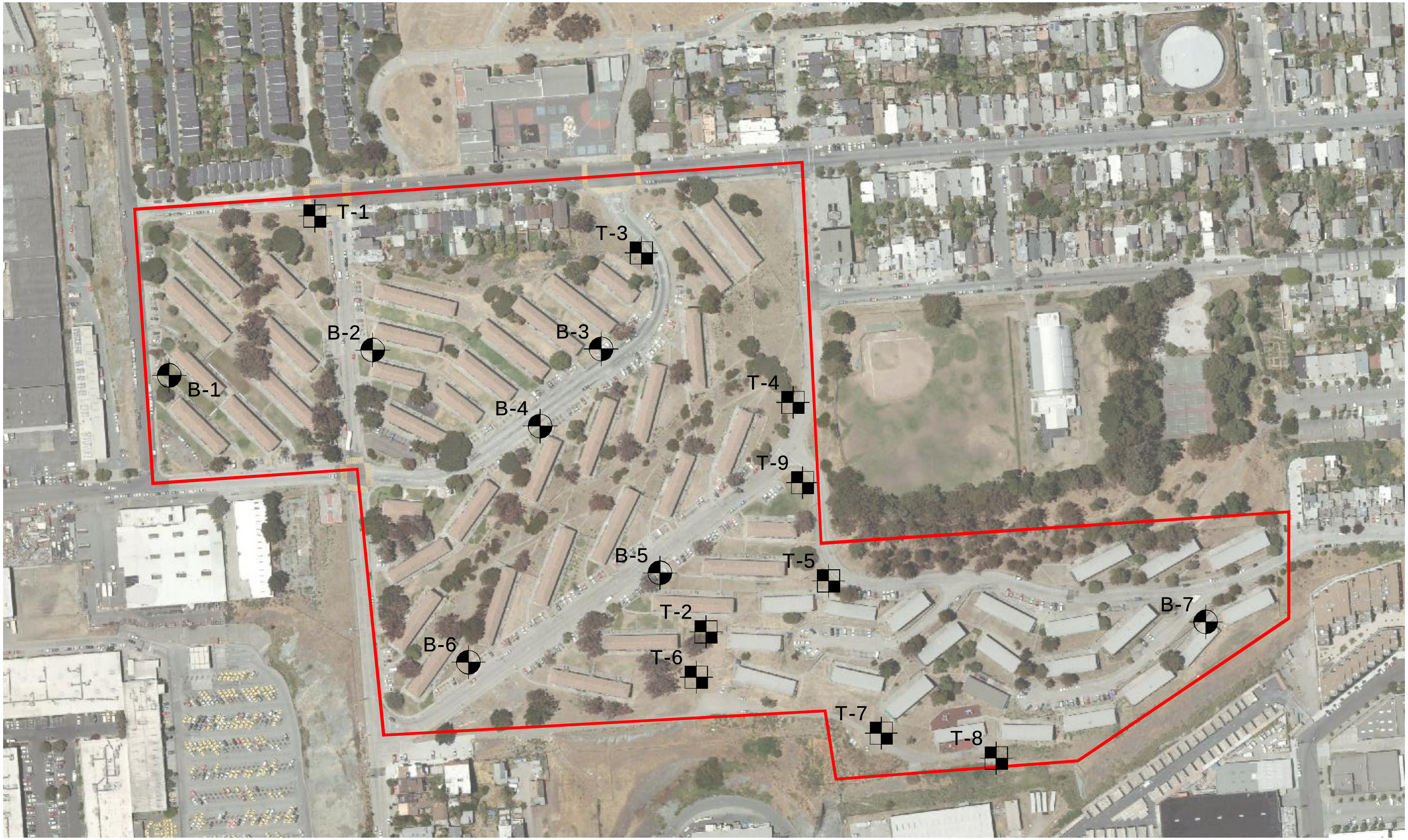
TOPOGRAPHIC MAP
POTRERO ANNEX AND TERRACE
SAN FRANCISCO, CALIFORNIA

PROJECT NO.: 8683.000.000	
DATE: JULY 2009	
DRAWN BY: SRP	CHECKED BY: BF

FIGURE NO.
2

ORIGINAL FIGURE PRINTED IN COLOR

G:\Drafting\DRAFTING2_Dwg\8683\000\GEX\8683000000-GEX-3-SitePlan-0709.dwg 2-16-10 02:53:05 PM dborde



EXPLANATION

B-7 APPROXIMATE LOCATION OF BORING

T-9 APPROXIMATE LOCATION OF TEST PIT

N

0 FEET 300
0 METERS 150

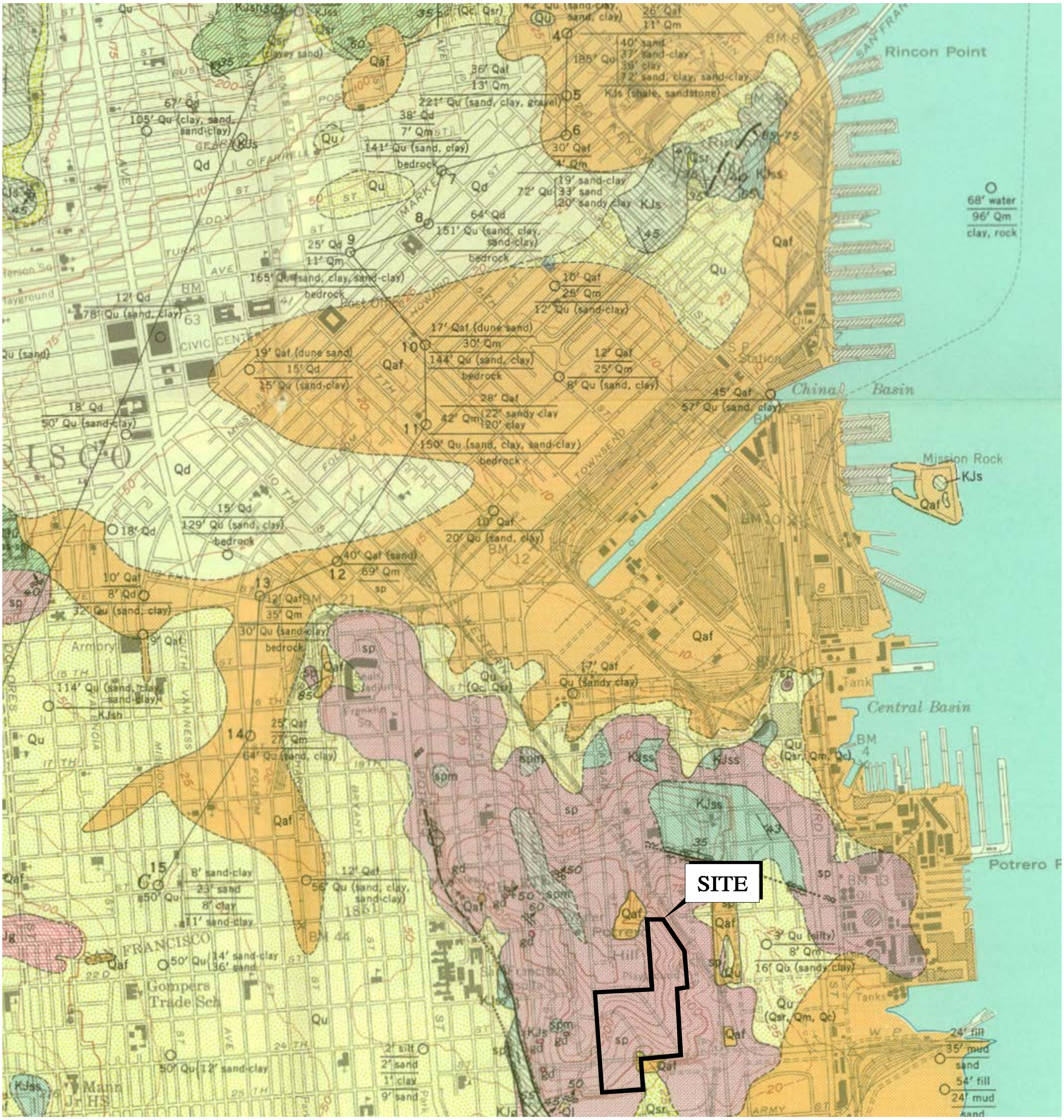
BASE MAP SOURCE: GOOGLE EARTH

ENGEO Expect Excellence

SITE PLAN
POTRERO ANNEX AND TERRACE
SAN FRANCISCO, CALIFORNIA

PROJECT NO.: 8683.000.000	
DATE: JULY 2009	
DRAWN BY: SRP	CHECKED BY: BF

FIGURE NO. 3



EXPLANATION

Qaf ARTIFICAL FILL

Qsr SLOPE DEBRIS AND RAVINE FILL

Sp SERPENTINE

N

0 FEET 2000

0 METERS 1000

BASE MAP SOURCE: SCHLOCKER, 1958

ENGEO Expect Excellence	REGIONAL GEOLOGIC MAP POTRERO ANNEX AND TERRACE SAN FRANCISCO, CALIFORNIA	PROJECT NO.: 8683.000.000 DATE: JULY 2009 DRAWN BY: SRP CHECKED BY: BF	FIGURE NO 4

G:\Drafting\DRAFTING2_Dwg\8683\000\GEX\8683000000-GEX-4-RegionalGeology-0709.dwg 2-16-10 02:49:43 PM dborde

ORIGINAL FIGURE PRINTED IN COLOR

EXPLANATION

B-7 APPROXIMATE LOCATION OF BORING

T-7 APPROXIMATE LOCATION OF TEST PIT

APPROXIMATE LOCATION OF GEOLOGIC CONTACT; QUERIED WHERE INTERPRETED; DOTTED WHERE CONCEALED.

Qaf ARTIFICIAL FILL

SP-1 SERPENTINITE - (BLOCKY), MOTTLED DARK GRAY, PALE GREEN WITH BROWN IRON OXIDE STAINING ON FRACTURE SURFACES, MEDIUM STRONG, HIGHLY WEATHERED, VERY CLOSELY FRACTURED, ABUNDANT PALE GREEN COATINGS ON FRACTURE SURFACES

SP-2 SERPENTINITE - (BLOCKY , LOWER DEGREE OF ALTERATION), MOTTLED DARK GRAY WITH SOME PALE GREEN COATINGS ON FRACTURES, MEDIUM STRONG TO STRONG, MODERATELY WEATHERED, VERY CLOSELY FRACTURED, OCCASIONAL SLICKENSIDED SURFACES.

SP-3 SERPENTINITE - (REDDISH BROWN), MOTTLED DARK GRAYISH GREEN AND REDDISH BROWN, STRONG TO VERY STRONG, MODERATELY WEATHERED WITHIN UPPER FOOT AND SLIGHTLY WEATHERED BELOW, MODERATELY FRACTURED, SOME IRON OXIDE STAINING ON FRACTURE SURFACES.

SP-4 SERPENTINITE - (PALE BLUE), MOTTLED DARK GRAY AND PALE BLUE, MODERATELY STRONG, MODERATELY TO HIGHLY WEATHERED, CLOSELY FRACTURED, SOME FEO STAINING ON FRACTURE SURFACES, OCCASIONAL SLICKENSIDED SURFACES WITH PALE GREEN COATING.

55 STRIKE AND DIP OF FOLIATION

55 STRIKE AND DIP OF JOINT

N

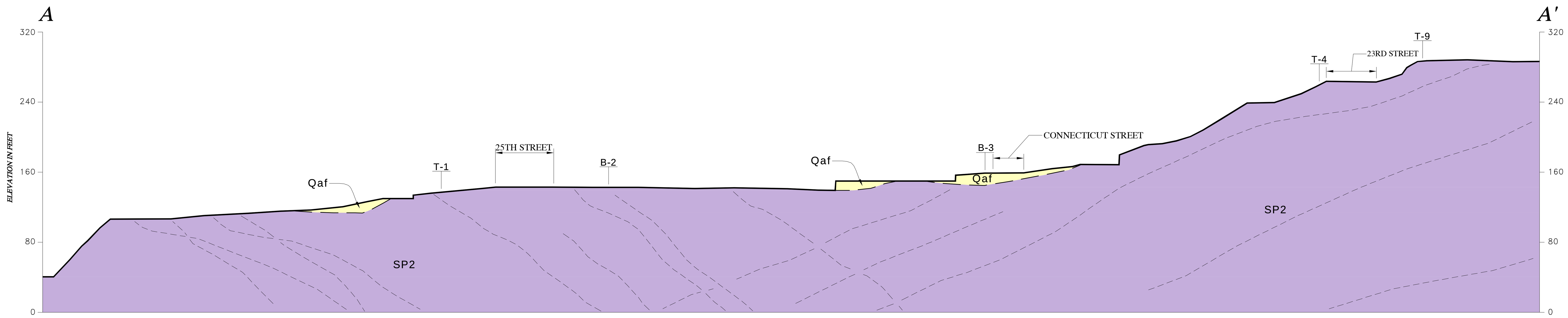
0 FEET 120
0 METERS 60

BASE MAP SOURCE: USGS TERRASERVER

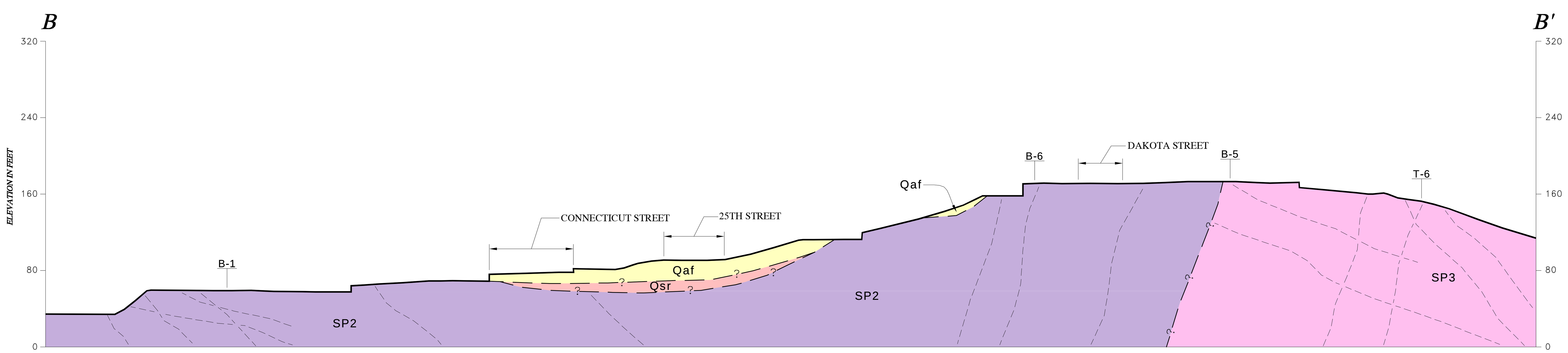
ENGEO Expect Excellence	GEOLOGIC MAP POTRERO ANNEX AND TERRACE SAN FRANCISCO, CALIFORNIA	PROJECT NO.: 8683.000.000 DATE: JULY 2009 DRAWN BY: PC CHECKED BY: BF	FIGURE NO. 5

ORIGINAL FIGURE PRINTED IN COLOR

G:\Drafting\DRAFTING2_Dwg\8683\000\GEX\8683000000-GEX-5-Geology-0709.dwg 2-16-10 02:48:47 PM dborde



SECTION A-A'
1"=80'



SECTION B-B'
1"=80'

EXPLANATION

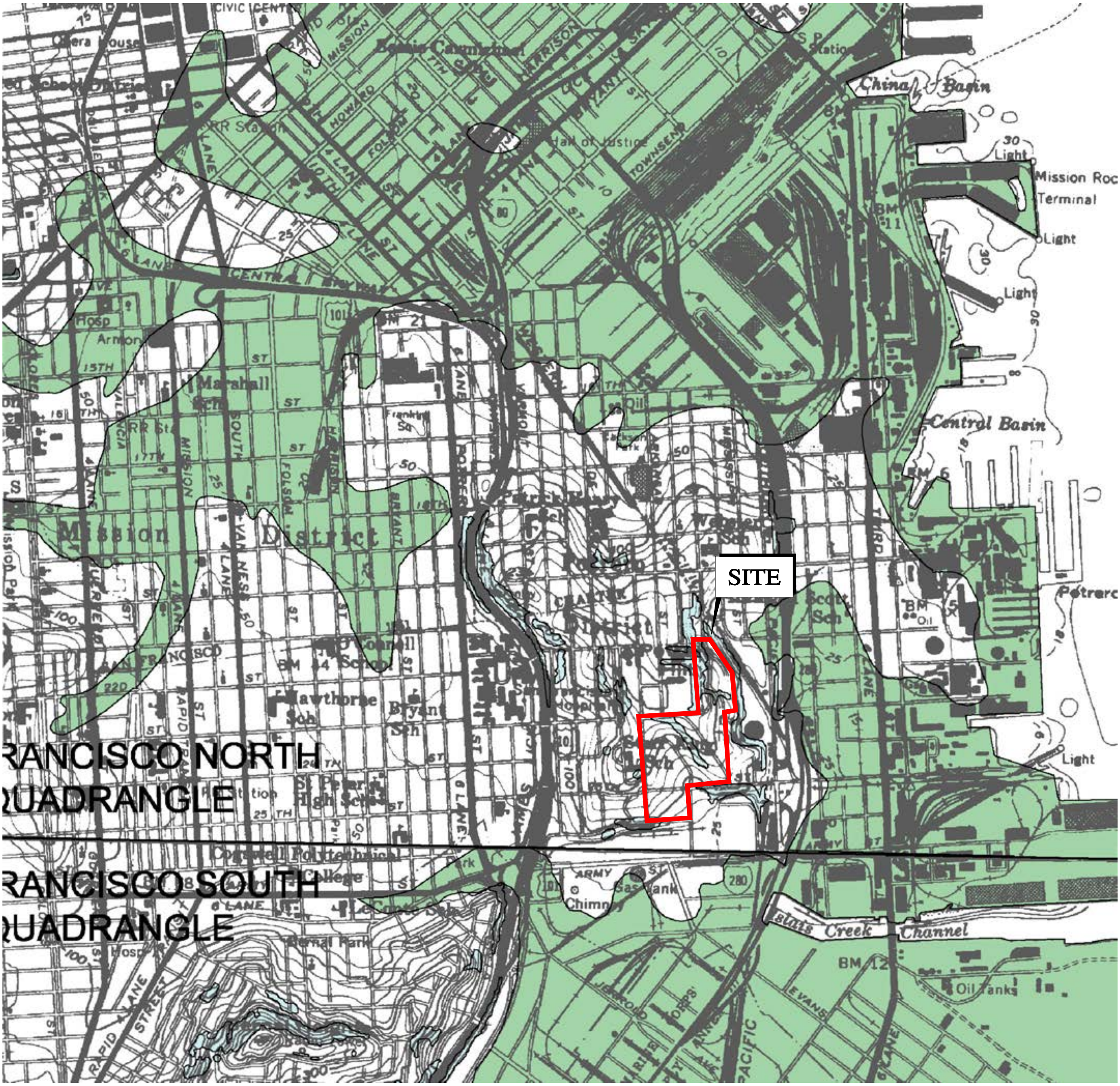
Qaf	ARTIFICIAL FILL
Qsr	QUATERNARY SLOPE WASH AND RAVINE FILL
SP-2	SERPENTINITE - (BLOCKY, LOWER DEGREE OF ALTERATION), MOTTLED DARK GRAY WITH SOME PALE GREEN COATINGS ON FRACTURES, MEDIUM STRONG TO STRONG, MODERATELY WEATHERED, VERY CLOSELY FRACTURED, OCCASIONAL SLICKENSIDED SURFACES.
SP-3	SERPENTINITE - (REDDISH BROWN), MOTTLED DARK GRAYISH GREEN AND REDDISH BROWN, STRONG TO VERY STRONG, MODERATELY WEATHERED WITHIN UPPER FOOT AND SLIGHTLY WEATHERED BELOW, MODERATELY FRACTURED, SOME IRON OXIDE STAINING ON FRACTURE SURFACES.

ENGEO
Expect Excellence

GEOLOGIC CROSS SECTIONS
POTRERO ANNEX AND TERRACE
SAN FRANCISCO, CALIFORNIA

PROJECT NO.: 8683.000.000
DATE: JULY 2009
DRAWN BY: PC
CHECKED BY: BF
FIGURE NO. 6

G:\Drafting\DRAFTING2_Dwg\8683\000\GEX\8683000000-GEX-6-CrossSectionsy-0709.dwg 2-16-10 02:47:46 PM dborde



EXPLANATION

Liquefaction

Areas where historic occurrence of liquefaction, or local geological, geotechnical and groundwater conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.

Earthquake-Induced Landslides

Areas where previous occurrence of landslide movement, or local topographic, geological, geotechnical and subsurface water conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.

N

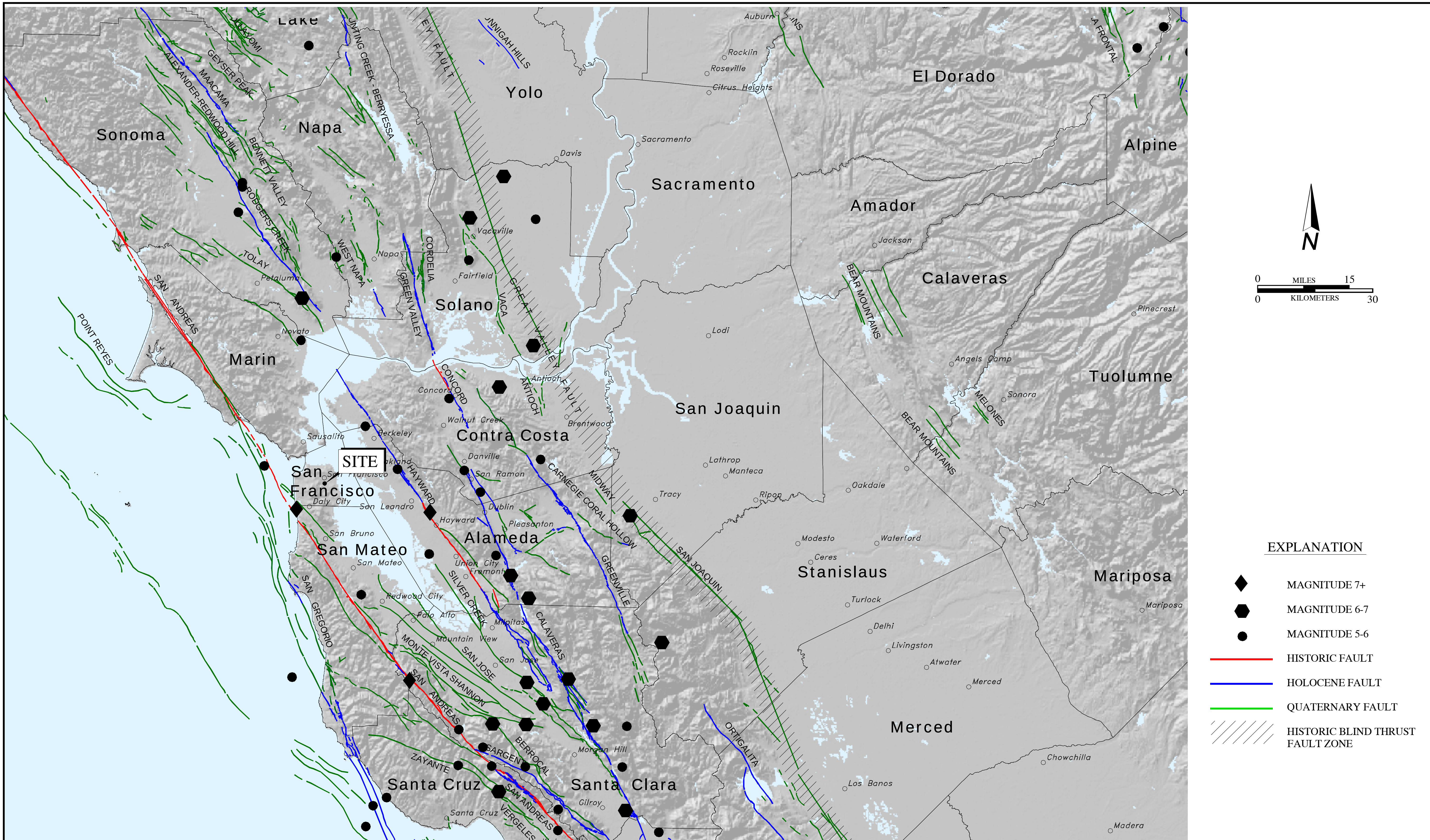
0 FEET 2000
0 METERS 1000

BASE MAP SOURCE: CITY AND COUNTY OF SAN FRANCISCO, 2001

ENGEO Expect Excellence	SEISMIC HAZARD ZONE MAP POTRERO ANNEX AND TERRACE SAN FRANCISCO, CALIFORNIA	PROJECT NO.: 8683.000.000 DATE: JULY 2009 DRAWN BY: SRP CHECKED BY: BF	FIGURE NO. 7

G:\Drafting\DRAFTING2_Dwg\8683\000\GEX\8683000000-GEX-7-SeismicHazardZones-0709.dwg 2-16-10 02:46:43 PM dborde

ORIGINAL FIGURE PRINTED IN COLOR

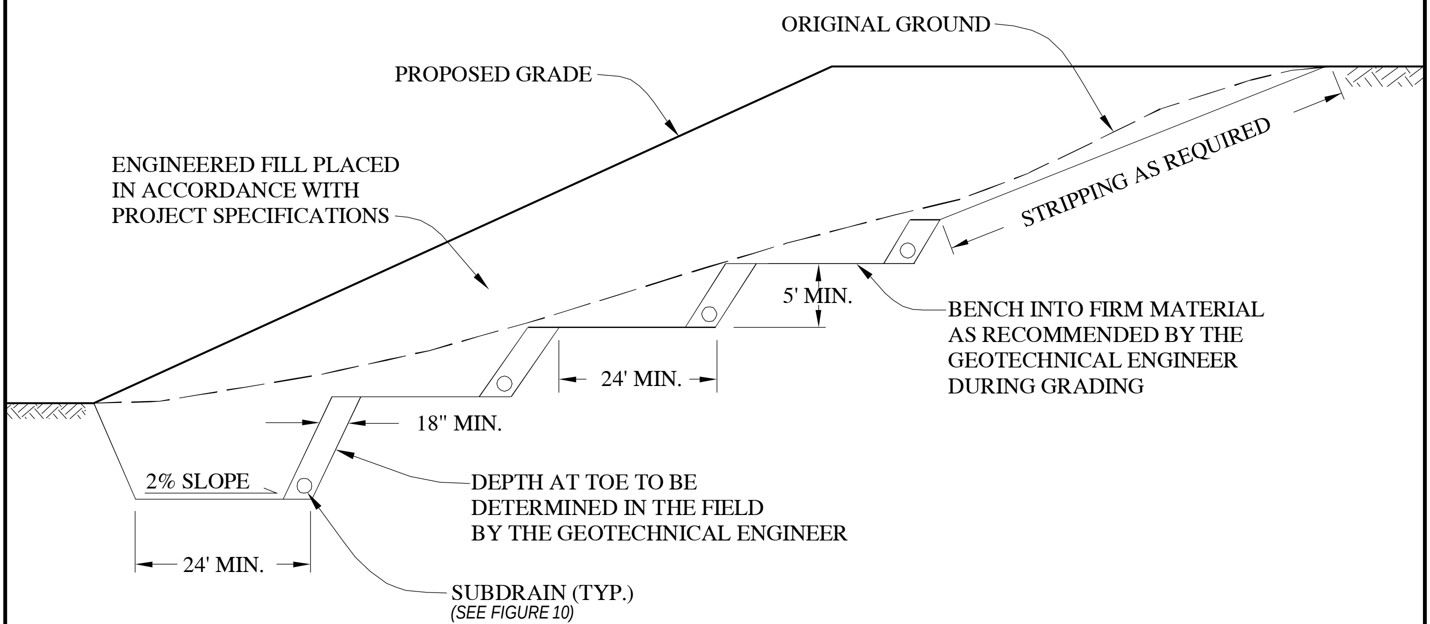


BASE MAP SOURCE:
U.S.G.S. 1-ARC SECOND S.R.T.M. DATABASE
U.S.G.S. QUATERNARY FAULT DATABASE, MARCH, 2006
U.S.G.S. HISTORIC EARTHQUAKE DATABASE (1800-2000)

ENGEO Expect Excellence	REGIONAL FAULTING AND SEISMICITY POTRERO ANNEX AND TERRACE SAN FRANCISCO, CALIFORNIA	PROJECT NO.: 8683.000.000 DATE: JULY 2009 DRAWN BY: SRP CHECKED BY: BF	FIGURE NO. 8

ORIGINAL FIGURE PRINTED IN COLOR

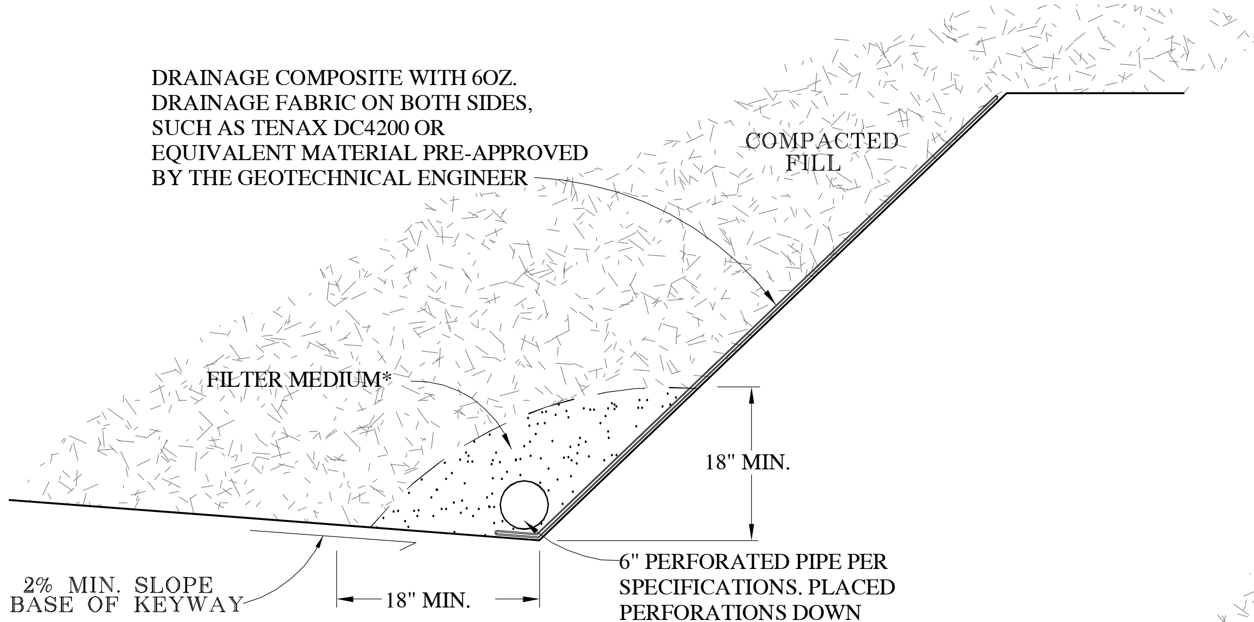
G:\Drafting\DRAFTING2_Dwg\8683\000\GEX\8683000000-GEX-8-FaultMap-0709.dwg 2-16-10 02:45:43 PM



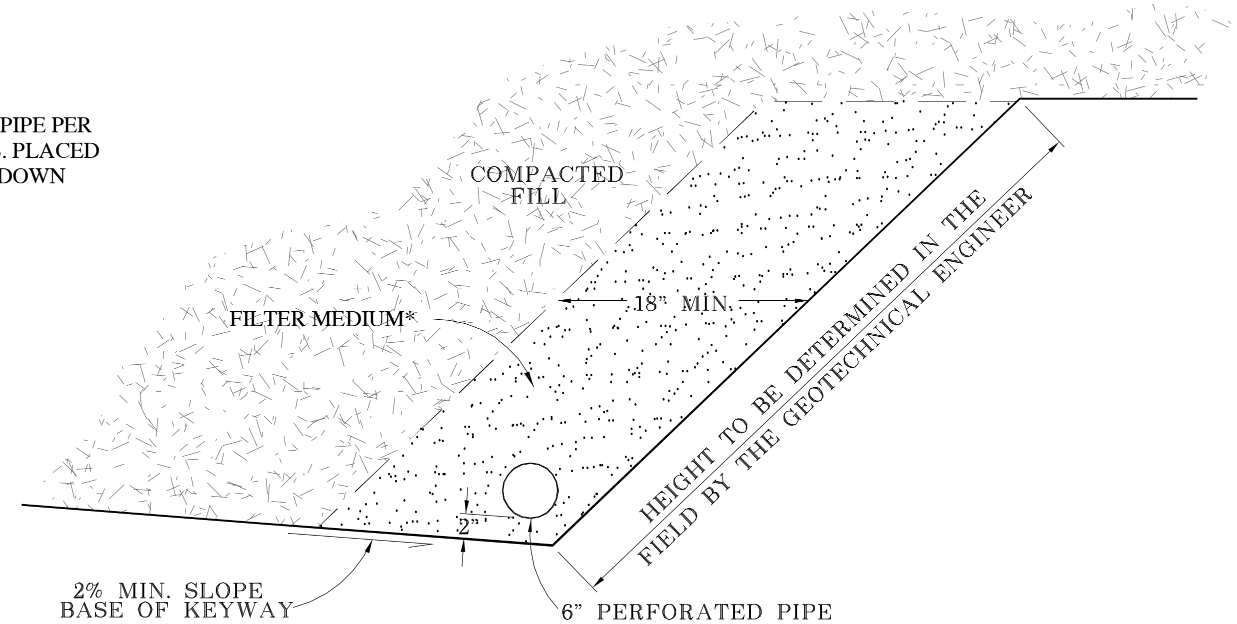
NO SCALE

ENGEO Expect Excellence	TYPICAL KEYWAY DETAIL POTRERO ANNEX AND TERRACE SAN FRANCISCO, CALIFORNIA	PROJECT NO.: 8683.000.000 DATE: JULY 2009 DRAWN BY: DLB CHECKED BY: BF	FIGURE NO. 9

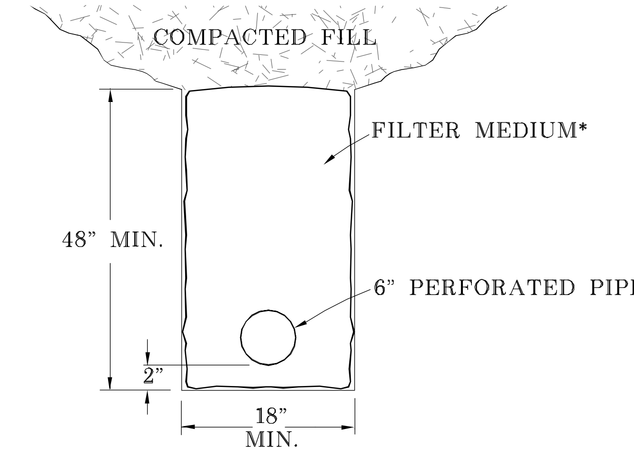
G: \Drafting\DRAFTING2_Dwg\8683\000\GEX\8683000000-GEX-9-KeyDetail-0709.dwg 2-16-10 02:40:26 PM dborde



KEYWAY SUBDRAIN - OPTION 1



KEYWAY SUBDRAIN - OPTION 2



SWALE SUBDRAIN

*FILTER MEDIUM

ALTERNATIVE A

CLASS 2 PERMEABLE MATERIAL

MATERIAL SHALL CONSIST OF CLEAN, COARSE SAND AND GRAVEL OR CRUSHED STONE, CONFORMING TO THE FOLLOWING GRADING REQUIREMENTS:

SIEVE SIZE	% PASSING SIEVE
1"	100
3/4"	90–100
3/8"	40–100
#4	25–40
#8	18–33
#30	5–15
#50	0–7
#200	0–3

ALTERNATIVE B

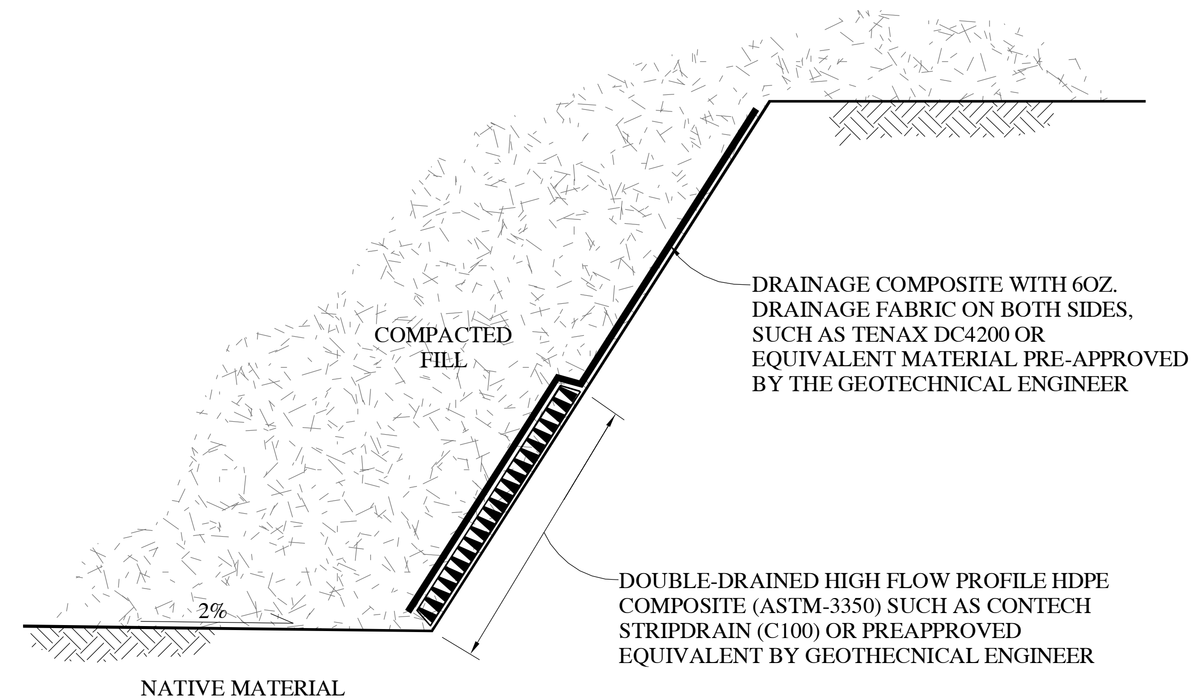
CLEAN CRUSHED ROCK OR GRAVEL WRAPPED IN FILTER FABRIC

ALL FILTER FABRIC SHALL MEET THE FOLLOWING MINIMUM AVERAGE ROLL VALUES UNLESS OTHERWISE SPECIFIED BY ENGEO:

GRAB STRENGTH (ASTM D-4632)	180 lbs
MASS PER UNIT AREA (ASTM D-4751)	6 oz/yd^2
APPARENT OPENING SIZE (ASTM D-4751)	70-100 U.S. STD. SIEVE
FLOW RATE (ASTM D-4491)	80 gal/min/ft
PUNCTURE STRENGTH (ASTM D-4833)	80 lbs

NOTES:

1. ALL PIPE JOINTS SHALL BE GLUED
2. ALL PERFORATED PIPE PLACED PERFORATIONS DOWN
3. 1% FALL (MINIMUM) ON ALL TRENCHES AND DRAIN LINES



ALTERNATE KEYWAY SUBDRAIN - OPTION 3

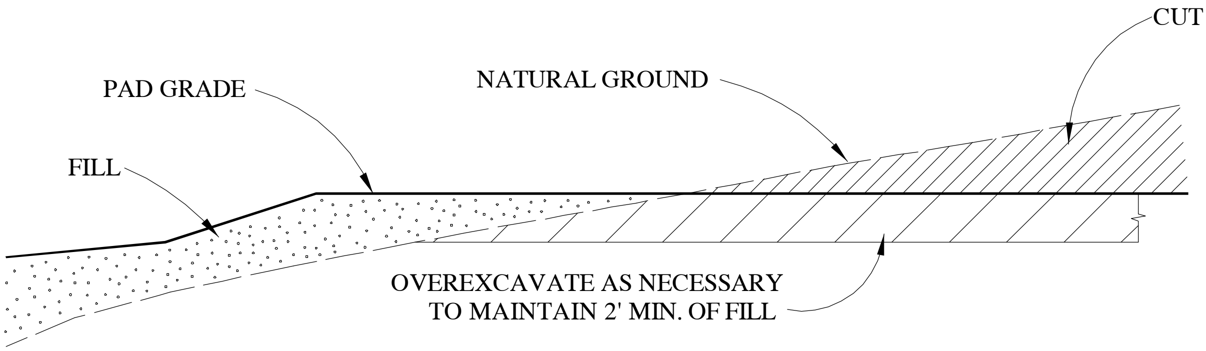
(FOR DEPTHS LESS THAN 30 FEET)

NO SCALE

ENGEO
Expect Excellence

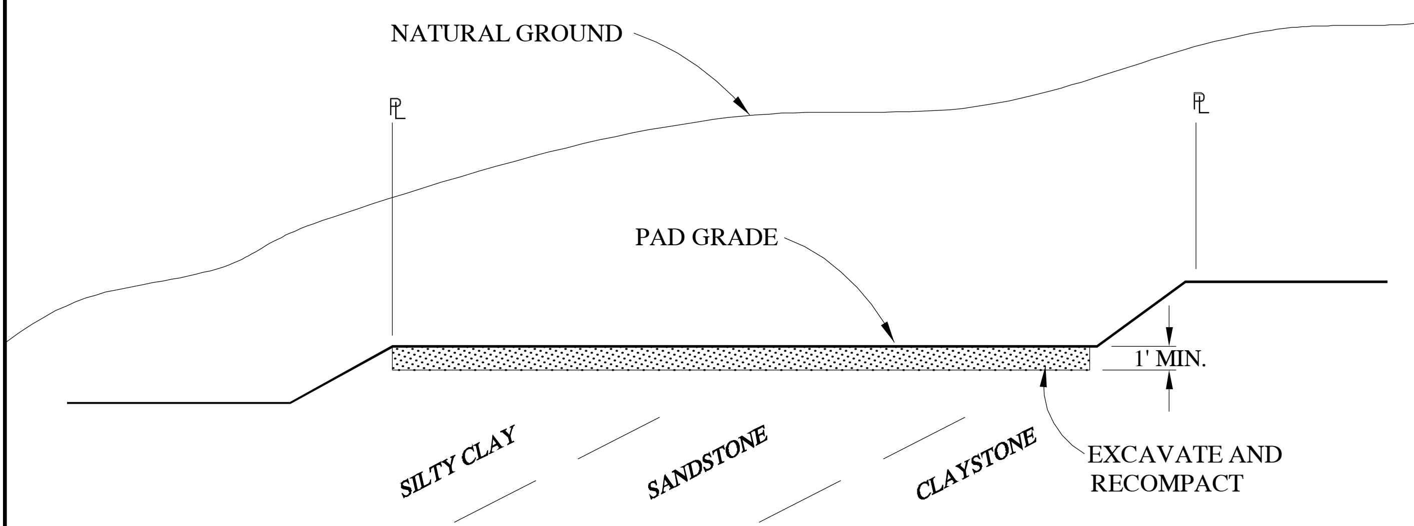
TYPICAL KEYWAY SUBDRAIN DETAILS
POTRERO ANNEX AND TERRACE
SAN FRANCISCO, CALIFORNIA

PROJECT NO.: 8683.000.000
DATE: JULY 2009
DRAWN BY: SRP
CHECKED BY: BF
FIGURE NO. 10



WHERE LOTS ARE PARTIALLY IN FILL, AND PARTIALLY IN CUT, THE CUT PORTION MUST BE OVEREXCAVATED AS SHOWN.

CUT/FILL LOT



WHERE LOTS ARE COMPLETELY IN CUT, THE UPPER 1' MIN. SHOULD BE EXCAVATED AND RECOMPACTED AS SHOWN

CUT LOT

NO SCALE

ENGEO
Expect Excellence

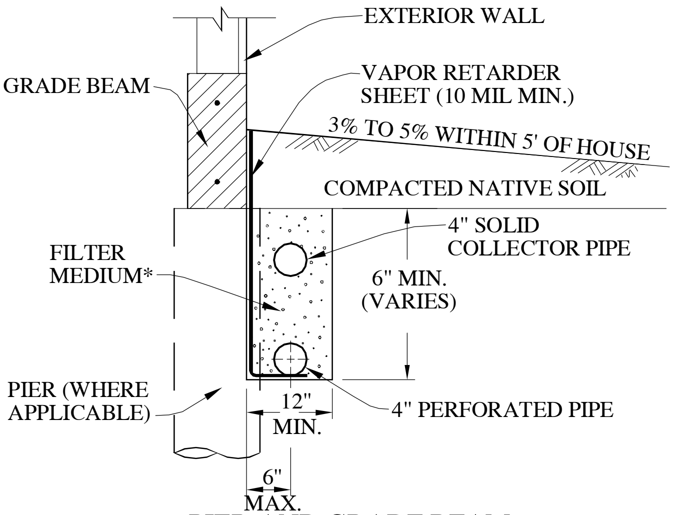
CUT AND TRANSITION LOT SUBEXCAVATION DETAIL

POTRERO ANNEX AND TERRACE

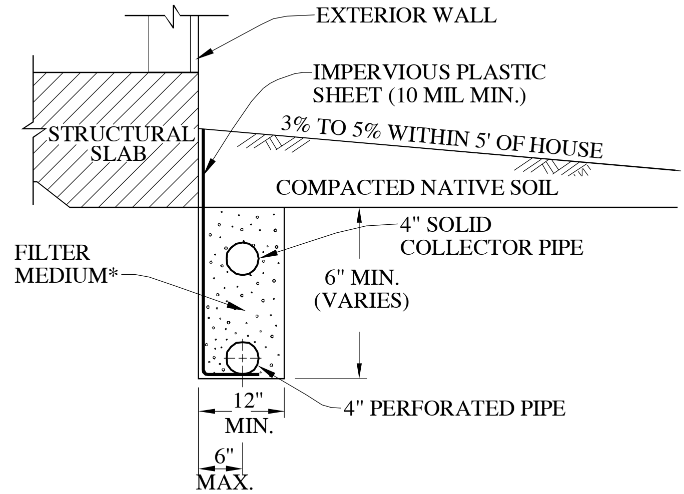
SAN FRANCISCO, CALIFORNIA

PROJECT NO.: 8683.000.000		FIGURE NO. 11
DATE: JULY 2009		
DRAWN BY: SRP	CHECKED BY: BF	

G:\Drafting\DRAFTING2_Dwg\8683\000\GEX\8683000000-GEX-11-CutFillDetail-0709.dwg 2-16-10 02:38:44 PM dborde

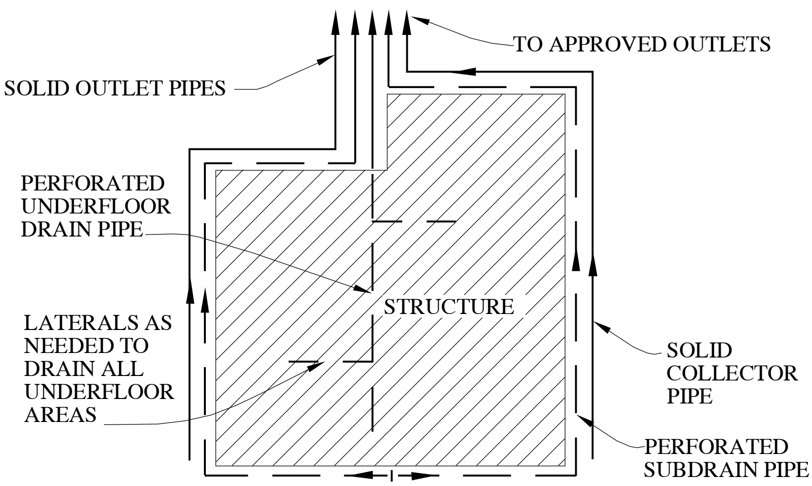


PIER AND GRADE BEAM

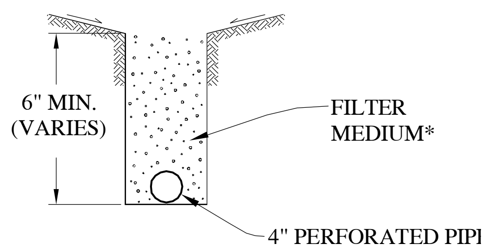


STRUCTURAL SLAB

COMBINED SUBDRAIN AND PERIMETER DRAIN



TYPICAL FOUNDATION SUBDRAIN PLAN



UNDERFLOOR DRAIN

NOTES:

1. ALL PIPE JOINTS SHALL BE GLUED

2. ALL PERFORATED PIPE PLACED PERFORATIONS DOWN

3. 1% FALL (MINIMUM) ON ALL TRENCHES AND DRAIN LINES

4. THE CLOSED COLLECTOR AND THE PERIMETER SUBDRAIN CAN BE CONSTRUCTED IN A SINGLE TRENCH, IF DESIRED. HOWEVER, THE CLOSED COLLECTOR PIPE MUST BE PLACED ABOVE THE SUBDRAIN PIPE, AND IN NO CASE SHOULD THE TWO SYSTEMS BE INTERCONNECTED

**FILTER MEDIUM*

ALTERNATIVE A - CLASS 2 PERMEABLE MATERIAL

MATERIAL SHALL CONSIST OF CLEAN, COARSE SAND AND GRAVEL OR CRUSHED STONE, CONFORMING TO THE FOLLOWING GRADING REQUIREMENTS:

SIEVE SIZE	% PASSING SIEVE
1"	100
3/4"	90-100
3/8"	40-100
#4	25-40
#8	18-33
#30	5-15
#50	0-7
#200	0-3

ALTERNATIVE B - CLEAN CRUSHED ROCK OR GRAVEL WRAPPED IN FILTER FABRIC

ALL FILTER FABRIC SHALL MEET THE FOLLOWING MINIMUM AVERAGE ROLL VALUES UNLESS OTHERWISE SPECIFIED BY ENGEO:

GRAB STRENGTH (ASTM D-4632)	180 lbs
MASS PER UNIT AREA (ASTM D-4751)	6 oz/yd^2
APPARENT OPENING SIZE (ASTM D-4751)	70-100 U.S. STD. SIEVE
FLOW RATE (ASTM D-4491)	80 gal/min/ft^2
PUNCTURE STRENGTH (ASTM D-4833)	80 lbs

NO SCALE

ENGEO
Expect Excellence

TYPICAL FOUNDATION DRAINAGE DETAILS

POTRERO ANNEX AND TERRACE

SAN FRANCISCO, CALIFORNIA

PROJECT NO.:	8683.000.000
DATE:	JULY 2009
DRAWN BY:	SRP
CHECKED BY:	BF
FIGURE NO.	12

G:\Drafting\DRAFTING2_Dwg\8683\000\GEX\8683000000-GEX-12-FoundationDrainagelDetail-0709.dwg 2-16-10 02:55:36 PM dborde

APPENDIX A

ENGEO Incorporated Boring Logs

APPENDIX A

KEY TO SOIL LOGS

MAJOR TYPES			DESCRIPTION
COARSE-GRAINED SOILS MORE THAN HALF OF MAT'L LARGER THAN #200 SIEVE	GRAVELS MORE THAN HALF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE	CLEAN GRAVELS WITH LESS THAN 5% FINES	GW - Well graded gravels or gravel-sand mixtures GP - Poorly graded gravels or gravel-sand mixtures
		GRAVELS WITH OVER 12 % FINES	GM - Silty gravels, gravel-sand and silt mixtures GC - Clayey gravels, gravel-sand and clay mixtures
	SANDS MORE THAN HALF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE	CLEAN SANDS WITH LESS THAN 5% FINES	SW - Well graded sands, or gravelly sand mixtures SP - Poorly graded sands or gravelly sand mixtures
		SANDS WITH OVER 12 % FINES	SM - Silty sand, sand-silt mixtures SC - Clayey sand, sand-clay mixtures
FINE-GRAINED SOILS MORE THAN HALF OF MAT'L SMALLER THAN #200 SIEVE	SILTS AND CLAYS LIQUID LIMIT 50 % OR LESS		ML - Inorganic silt with low to medium plasticity CL - Inorganic clay with low to medium plasticity OL - Low plasticity organic silts and clays
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50 %		MH - Elastic silt with high plasticity CH - Fat clay with high plasticity OH - Highly plastic organic silts and clays
	HIGHLY ORGANIC SOILS		PT - Peat and other highly organic soils

For fine-grained soils with 15 to 29% retained on the #200 sieve, the words "with sand" or "with gravel" (whichever is predominant) are added to the group name.

For fine-grained soil with >30% retained on the #200 sieve, the words "sandy" or "gravelly" (whichever is predominant) are added to the group name.

GRAIN SIZES

U.S. STANDARD SERIES SIEVE SIZE: 200, 40, 10, 4 — CLEAR SQUARE SIEVE OPENINGS: 3/4 ", 3", 12"

SILTS AND CLAYS	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

RELATIVE DENSITY

SANDS AND GRAVELS	BLOWS/FOOT (S.P.T.)
VERY LOOSE	0-4
LOOSE	4-10
MEDIUM DENSE	10-30
DENSE	30-50
VERY DENSE	OVER 50

CONSISTENCY

SILTS AND CLAYS	STRENGTH*
VERY SOFT	0-1/4
SOFT	1/4-1/2
MEDIUM STIFF	1/2-1
STIFF	1-2
VERY STIFF	2-4
HARD	OVER 4

MOISTURE CONDITION

DRY	Dusty, dry to touch
MOIST	Damp but no visible water
WET	Visible freewater

SAMPLER SYMBOLS

- Modified California (3" O.D.) sampler
- California (2.5" O.D.) sampler
- S.P.T. - Split spoon sampler
- Shelby Tube
- Continuous Core
- Bag Samples
- Grab Samples
- NR No Recovery

LINE TYPES

- ________ Solid - Layer Break
- – – – – – – Dashed - Gradational or approximate layer break

GROUND-WATER SYMBOLS

- Groundwater level during drilling
- Stabilized groundwater level

(S.P.T.) Number of blows of 140 lb. hammer falling 30" to drive a 2-inch O.D. (1-3/8 inch I.D.) sampler

* Unconfined compressive strength in tons/sq. ft., asterisk on log means determined by pocket penetrometer

ENGEO INCORPORATED

LOG OF BORING B1

ENGEO INCORPORATED

Geotechnical Exploration
Potrero Terrace
San Francisco, California
8683.000.000

DATE DRILLED: 6/16/2009
HOLE DEPTH: Approx. 5½ ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (): Approx. 70 ft.

LOGGED / REVIEWED BY: L. Chan / DEB
DRILLING CONTRACTOR: Ram Geotechnical
DRILLING METHOD: Solid Flight Auger
HAMMER TYPE: 140 lb. Rope and Cathead

Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count/Foot	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Limit	Atterberg Limits: Plasticity Index	Fines Content (% passing #200 sieve)	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
			CLAYEY SAND (SM), light brown, moist, fine-grained sand, (FILL)										
			SERPENTINITE, dark green, very weak (R1), very closely fractured, highly weathered										
						52/2.5"							
	1												
5						50/3.5"							
			Bottom of boring at approximately 5.5 feet below ground surface. Groundwater not encountered during drilling.										

LOG OF BORING B2

ENGEO INCORPORATED

Geotechnical Exploration
Potrero Terrace
San Francisco, California
8683.000.000

DATE DRILLED: 6/16/2009
HOLE DEPTH: Approx. 9½ ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (): Approx. 115 ft.

LOGGED / REVIEWED BY: L. Chan / DEB
DRILLING CONTRACTOR: Ram Geotechnical
DRILLING METHOD: Solid Flight Auger
HAMMER TYPE: 140 lb. Rope and Cathead

Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count/Foot	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Limit	Atterberg Limits: Plasticity Index	Fines Content (% passing #200 sieve)	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
			SANDY SILT (ML), light gray, stiff, moist, coarse-grained sand										
	1		SERPENTINITE, light grayish green, very weak (R1), completely weathered, with fragments of weak, moderately weathered serpentinite, friable.			21	36	25	11				
5	2		Becomes weak and closely fractured.			18							
			Becomes moderately weathered.			53/6"							
			Bottom of boring at approximately 9.5 feet below ground surface. Groundwater not encountered during drilling.										

LOG OF BORING B3

ENGEO INCORPORATED

Geotechnical Exploration
Potrero Terrace
San Francisco, California
8683.000.000

DATE DRILLED: 6/16/2009
HOLE DEPTH: Approx. 16½ ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (): Approx. 185 ft.

LOGGED / REVIEWED BY: L. Chan / DEB
DRILLING CONTRACTOR: Ram Geotechnical
DRILLING METHOD: Solid Flight Auger
HAMMER TYPE: 140 lb. Rope and Cathead

Depth in Feet	Depth in Meters	DESCRIPTION	Blow Count/Foot	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Limit	Atterberg Limits: Plasticity Index	Fines Content (% passing #200 sieve)	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
0		SILTY CLAY (CL), grayish brown, hard, moist, with rock fragments, trace fine-grained sand, (FILL)								
	1		44					17.8	94.2	
		CLAY (CH), dark brown, hard, moist, (Colluvium)		76	19	57	72	24.7	86.7	4.25*
5	2	Becomes black.	37					24.6	97	+4.5*
10	3	CLAY (CL), dark brown, hard, moist, trace rock fragments Difficult drilling (Qsr)	77					24.3	99.3	+4.5*
15	5	SERPENTINITE, dark green, very weak (R1), highly weathered, crushed	69							

what does the blue color mean?

Bottom of boring at approximately 16.5 feet below ground surface.
Groundwater not encountered during drilling.

ENGEO INCORPORATED

LOG OF BORING B4

Geotechnical Exploration
Potrero Terrace
San Francisco, California
8683.000.000

DATE DRILLED: 6/16/2009
HOLE DEPTH: Approx. 16½ ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (): Approx. 126 ft.

LOGGED / REVIEWED BY: L. Chan / DEB
DRILLING CONTRACTOR: Ram Geotechnical
DRILLING METHOD: Solid Flight Auger
HAMMER TYPE: 140 lb. Rope and Cathead

DESCRIPTION	Blow Count/Foot	Atterberg Limits: Liquid Limit	Plastic Limit	Plasticity Index	Fines Content (% passing #200 sieve)	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
CLAYEY SILT (CL), dark brown, moist, with sand, (FILL)								
CLAYEY SAND (SC), dark brown, very stiff, moist, with rock fragments, (FILL)	32					15.9	108.6	
SILTY CLAY (CL), yellowish brown, very stiff, moist, with rock fragments, trace coarse-grained sand, (Qsr)	26					26.7	96.2	3*
	29					66.4	28.9	2*
SERPENTINITE, dark green, very weak (R1), crushed	51/6"							
Difficult drilling								
Becomes light green	33							

Bottom of boring at approximately 16.5 feet below ground surface.
Groundwater not encountered during drilling.

LOG OF BORING B5

ENGEO INCORPORATED

Geotechnical Exploration
Potrero Terrace
San Francisco, California
8683.000.000

DATE DRILLED: 6/16/2009
HOLE DEPTH: Approx. 5½ ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (): Approx. 233 ft.

LOGGED / REVIEWED BY: L. Chan / DEB
DRILLING CONTRACTOR: Ram Geotechnical
DRILLING METHOD: Solid Flight Auger
HAMMER TYPE: 140 lb. Rope and Cathead

Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count/Foot	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Limit	Atterberg Limits: Plasticity Index	Fines Content (% passing #200 sieve)	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
			Difficult drilling										
			SERPENTINITE, dark green, very weak (R1), highly weathered, very thin foliated			54/6"							
	1												
5			Refusal. No recovery from sampler.			50/2.5"							
			Bottom of boring at approximately 5.5 feet below ground surface. Groundwater not encountered during drilling.										

LOG OF BORING B6

ENGEO INCORPORATED

Geotechnical Exploration
Potrero Terrace
San Francisco, California
8683.000.000

DATE DRILLED:	6/16/2009	LOGGED / REVIEWED BY:	L. Chan / DEB
HOLE DEPTH:	Approx. 5½ ft.	DRILLING CONTRACTOR:	Ram Geotechnical
HOLE DIAMETER:	6.0 in.	DRILLING METHOD:	Solid Flight Auger
SURF ELEV ():	Approx. 168 ft.	HAMMER TYPE:	140 lb. Rope and Cathead

Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count/Foot	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Limit	Atterberg Limits: Plasticity Index	Fines Content (% passing #200 sieve)	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
			SILTY CLAY (CL), dark brown, moist										
			SERPENTINITE, dark green, weak, highly weathered, closely fractured			50/3"							
	1		Very slow drilling										
5			No recovery.			50/2.5"							
			Bottom of boring at approximately 5.5 feet below ground surface. Groundwater not encountered during drilling.										

ENGEO INCORPORATED

LOG OF BORING B7

Geotechnical Exploration
Potrero Terrace
San Francisco, California
8683.000.000

DATE DRILLED: 6/16/2009
HOLE DEPTH: Approx. 13½ ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (): Approx. 165 ft.

LOGGED / REVIEWED BY: L. Chan / DEB
DRILLING CONTRACTOR: Ram Geotechnical
DRILLING METHOD: Solid Flight Auger
HAMMER TYPE: 140 lb. Rope and Cathead

Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count/Foot	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Limit	Atterberg Limits: Plasticity Index	Fines Content (% passing #200 sieve)	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
	1		SILTY SAND (SM), light gray, medium dense, moist, with rock fragments, (FILL)			36					12.5	112.4	
5	2		SANDY SILT (ML), dark brown, very stiff, moist, with rock fragments, (FILL)			30				24	19	99.3	
10	3, 4		SERPENTINITE, green, extremely weak (R0), completely weathered, laminated			22	36	27	9				
						55/6"							

Bottom of boring at approximately 16.5 feet below ground surface.
Groundwater not encountered during drilling.

APPENDIX B

ENGEO Exploratory Test Pit Logs

APPENDIX B

TEST PIT LOGS

Test Pit Number	Depth (Feet)	Description
TP-1	0 – 4.5	SILTY SAND (SM), mottled brown and dark gray, medium dense, moist, with gravel and occasional boulders. Gravel and boulders comprise angular fragments of serpentinite. (Artificial Fill)
	4.5- 6	SERPENTINITE, mottled dark gray with some pale green coatings on fractures, medium strong to strong, moderately weathered, very closely fractured, occasional slickensided surfaces. (Designated on map as SP-2)
		Bottom at 6 feet. No free groundwater encountered.
TP-2	0 – 0.5	SILTY CLAY (CL), mottled brown to dark brown, dry, medium stiff. (Thin native soil).
	0.5 – 3	SERPENTINITE, mottled dark grayish green and reddish brown, strong to very strong, moderately weathered within upper foot and slightly weathered below, moderately fractured, some FeO staining on fracture surfaces. (Designated on map as SP-3)
		Bottom at 3 feet. No free groundwater encountered.
TP-3	0 – 5	SILTY SAND (SM), mottled dark brown and brown, medium dense, moist, with gravel and occasional boulders. Gravel and boulders comprise angular fragments of serpentinite. Trace debris comprising brick, glass, and rusted iron straps. (Artificial Fill)

TEST PIT LOGS

Test Pit Number	Depth (Feet)	Description
	5 – 7	SERPENTINITE, mottled dark gray, pale green with brown FeO staining on fracture surfaces, medium strong, highly weathered, very closely fractured, abundant pale green coatings on fracture surfaces (Designated on map as SP-1) Bottom at 7 feet. No free groundwater encountered.
TP-4	0 – 0.4	SILTY SAND (SM), brown, loose, dry, with gravel. Gravel comprises angular fragments of serpentinite. (Thin residual soil).
	0.4 – 5	SERPENTINITE, mottled dark gray with some pale green coatings on fractures, medium strong, slightly to moderately weathered, very closely fractured. Faint shear fabric oriented E-W 30N (Designated on map as SP-2) Bottom at 5 feet. No free groundwater encountered.
TP-5	0 – 2.5	SILTY CLAY (CL), mottled dark brown, brown and gray, medium stiff, moist. Trace debris comprising iron pipes, plastic and wood debris. (Artificial Fill)
	2.5 - 5	SERPENTINITE, mottled dark gray, pale green with brown FeO staining on fracture surfaces, medium strong, highly weathered, very closely fractured to crushed, abundant pale green coatings on fracture surfaces (Designated on map as SP-1) Bottom at 7 feet. No free groundwater encountered.
TP-6	0 – 1	SILTY CLAY (CL), mottled brown to dark brown, moist, medium stiff with sand and gravel. Sand and gravel comprises angular fragments of serpentinite. (Thin residual soil).
	1 – 3.5	SERPENTINITE, mottled dark grayish green and reddish brown, strong to very strong, moderately weathered within upper foot and slightly weathered below, moderately fractured, some FeO staining on fracture surfaces. (Designated on map as SP-3)

TEST PIT LOGS

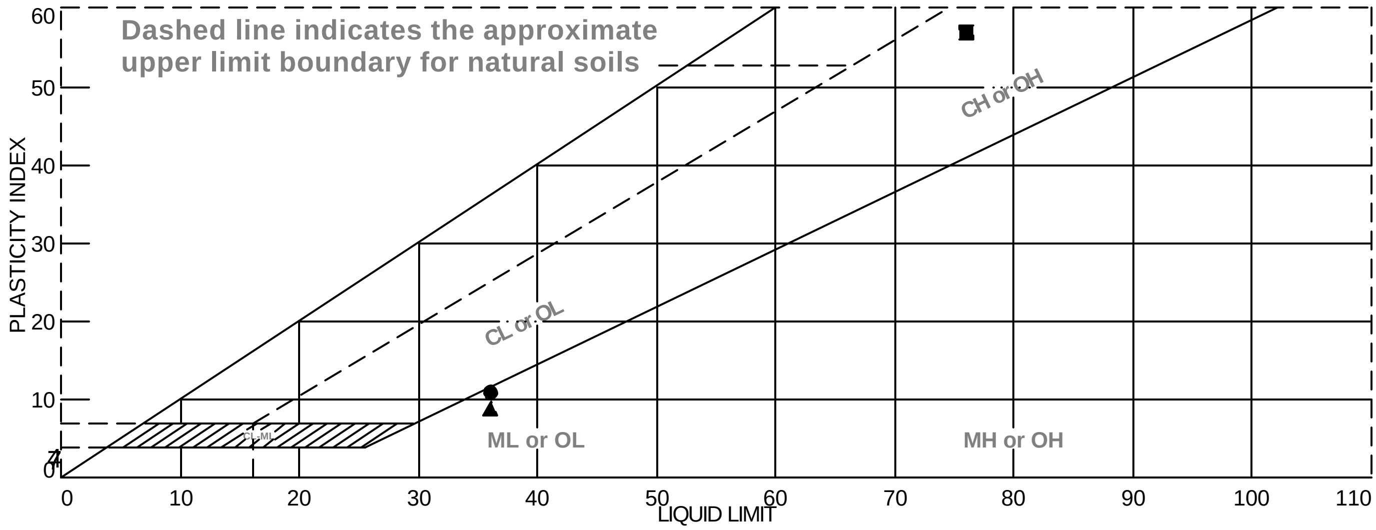
Test Pit Number	Depth (Feet)	Description
		Bottom at 3.5 feet. No free groundwater encountered.
TP-7	0 – 0.5	SILTY SAND (SM), brown, loose to medium dense, dry, with gravel. Gravel comprises angular fragments of serpentinite. (Thin residual soil).
	0.5 – 6.0	SERPENTINITE, mottled dark gray and pale blue, moderately strong, moderately to highly weathered, closely fractured, some FeO staining on fracture surfaces, occasional slickensided surfaces with pale green coating. Predominant joint set N50E 55S (Designated on map as SP-4)
		Bottom at 6.0 feet. No free groundwater encountered.
TP-8	0 – 8	SILTY SAND (SM), mottled dark brown and brown, loose to medium dense, moist, with gravel and occasional boulders. Gravel and boulders comprise angular fragments of serpentinite. Trace debris comprising glass, and wood fragments. (Artificial Fill)
	6 - 9	SERPENTINITE, mottled dark gray and pale blue, moderately strong, moderately to highly weathered, closely fractured, some FeO staining on fracture surfaces, occasional slickensided surfaces with pale green coating. (Designated on map as SP-4)
		Bottom at 9.0 feet. No free groundwater encountered.
TP-9	0 – 1	CLAY with some SILT to trace sand (CH), dark brown, medium stiff, moist, high plasticity.
	1 – 3.5	SERPENTINITE, mottled dark gray with some pale green coatings on fractures, medium strong, moderately weathered, very closely fractured. (Designated on map as SP-2)
		Bottom at 3.5 feet. No free groundwater encountered.

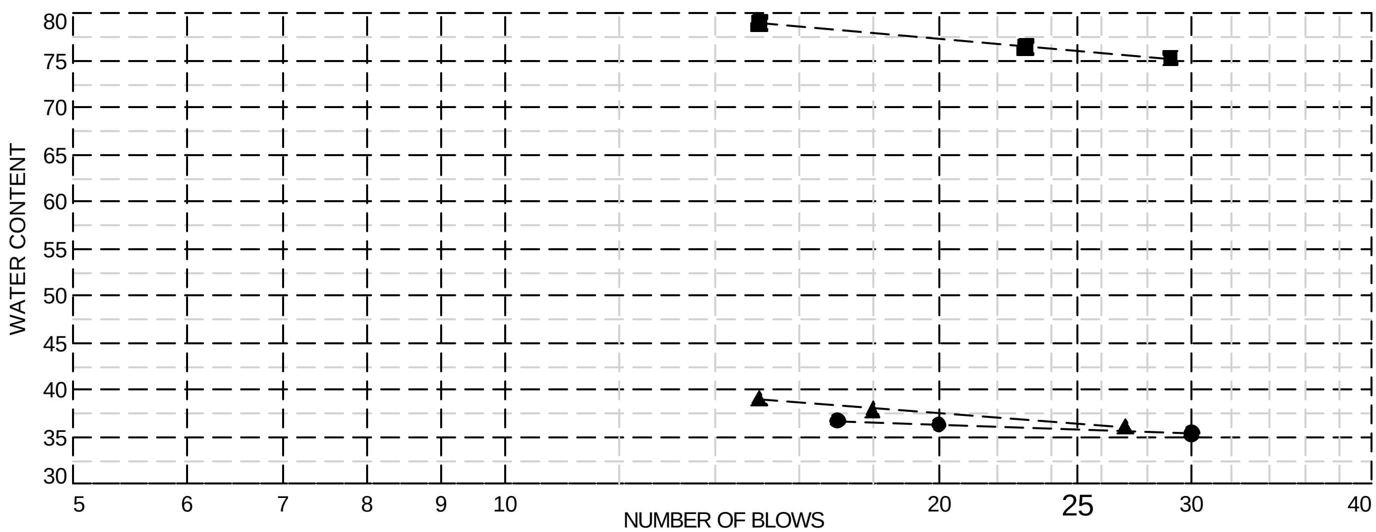
APPENDIX C

ENGEO Incorporated Laboratory Test Data

APPENDIX C

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Very dark grayish brown clayey SILT to silty CLAY	36	25	11			ML-CL
■	Very dark grayish brown CLAY with sand.	76	19	57		71.9	CH
▲	Dark greenish gray clayey SILT	36	27	9			ML

Project No. 8683.000.000 **Client:** Bridge Housing

Project: Potrero Annex and Terrace, San Francisco, CA

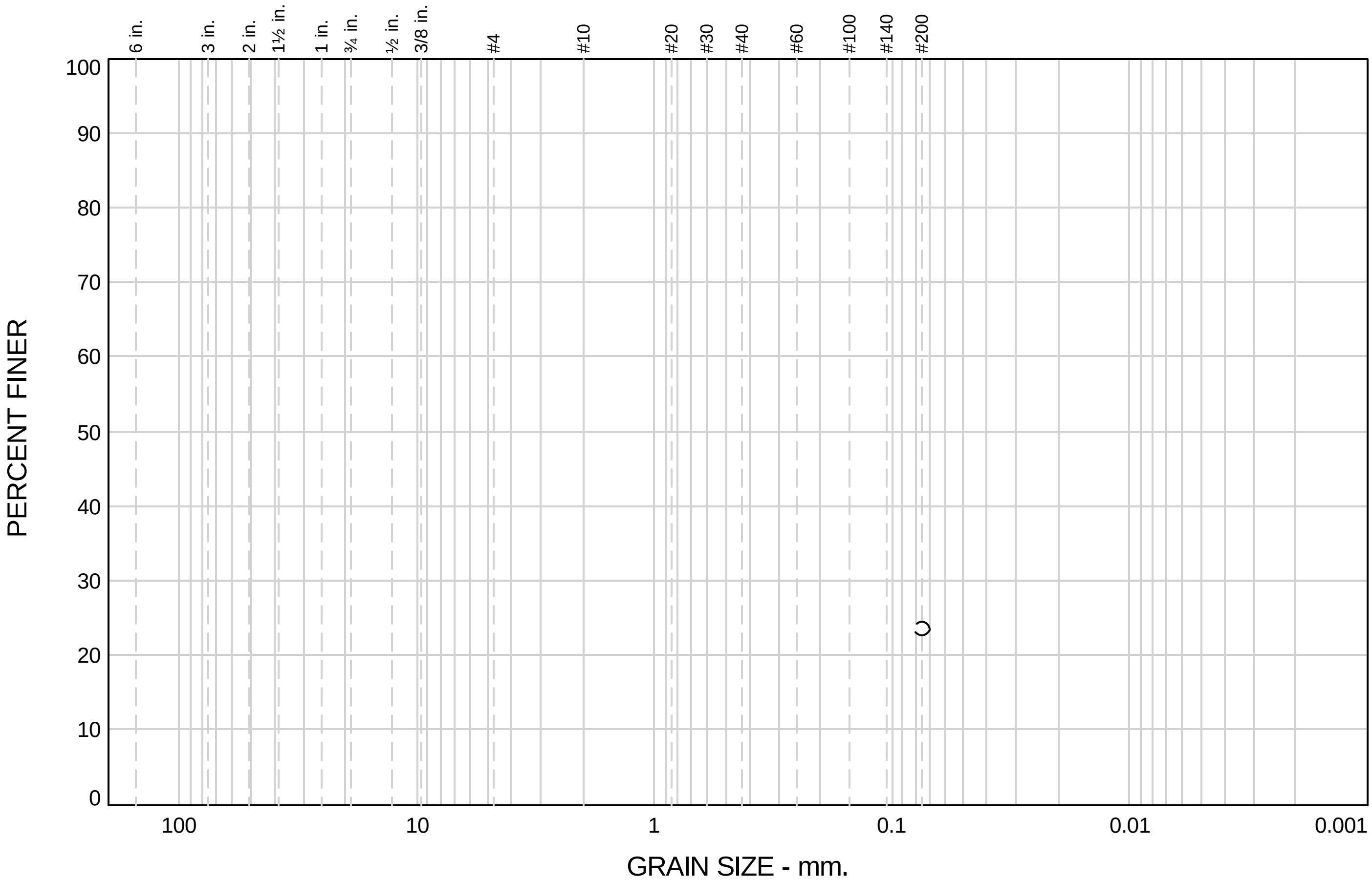
● **Sample Number:** B2 @ 3
■ **Sample Number:** B3 @ 3.5
▲ **Sample Number:** B7 @ 9

Remarks:

ENGEO INCORPORATED
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS MATERIALS TESTING

Plate

Particle Size Distribution Report



% Cobbles	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						23.6	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	23.6		

* (no specification provided)

Soil Description

Very dark grayish brown clayey SAND with gravel.

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

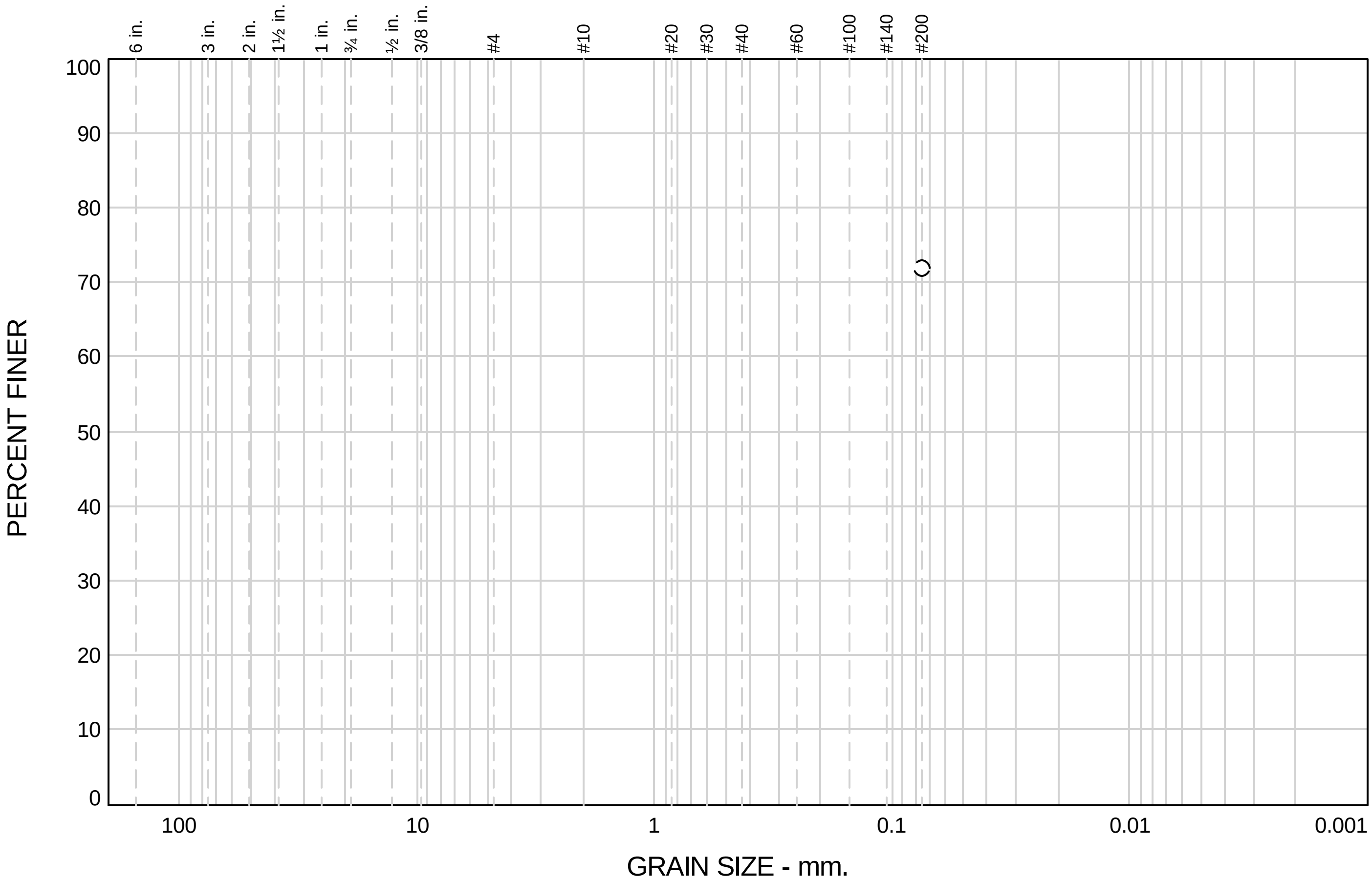
Sample No.: B7 @ 6 **Source of Sample:** **Date:** 06/29/09
Location: **Elev./Depth:**

ENGEO INCORPORATED
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
MATERIALS TESTING

Client: Bridge Housing
Project: Potrero Annex and Terrace, San Francisco, CA

Project No: 8683.000.000 **Plate**

Particle Size Distribution Report



% Cobbles	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						71.9	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	71.9		

* (no specification provided)

Soil Description

Very dark grayish brown CLAY with sand.

Atterberg Limits

PL= 19 LL= 76 PI= 57

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CH AASHTO=

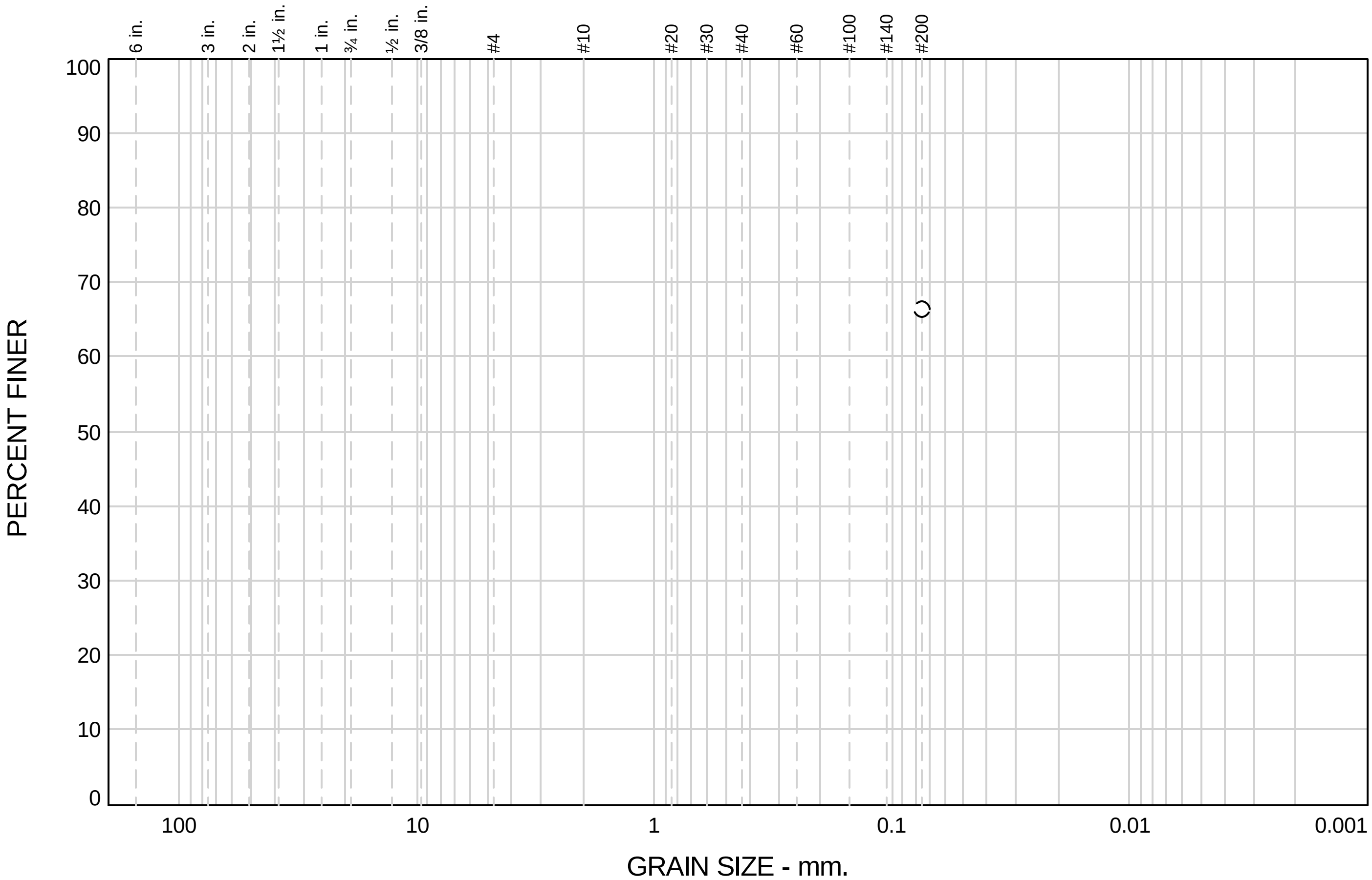
Remarks

Sample No.: B3 @ 3.5 **Source of Sample:** **Date:** 06/29/09
Location: **Elev./Depth:**

ENGEO INCORPORATED — GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS, MATERIALS TESTING

Client: Bridge Housing
Project: Potrero Annex and Terrace, San Francisco, CA
Project No: 8683.000.000 **Plate**

Particle Size Distribution Report



% Cobbles	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						66.4	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	66.4		

* (no specification provided)

Soil Description

Olive sandy CLAY.

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Sample No.: B4 @ 9 **Source of Sample:** **Date:** 06/29/09
Location: **Elev./Depth:**

ENGEO INCORPORATED
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
MATERIALS TESTING

Client: Bridge Housing
Project: Potrero Annex and Terrace, San Francisco, CA

Project No: 8683.000.000 **Plate**

A P P E N D I X D

APPENDIX D

Guide Contract Specifications

GUIDE CONTRACT SPECIFICATIONS

PART I - EARTHWORK

PREFACE

These specifications are intended as a guide for the earthwork performed at the subject development project. If there is a conflict between these specifications (including the recommendations of the geotechnical report) and agency or code requirements, it should be brought to the attention of ENGEO and Owner prior to contract bidding.

PART 1 - GENERAL

1.01 WORK COVERED

A. Grading, excavating, filling and backfilling, including trenching and backfilling for utilities as necessary to complete the Project as indicated on the Drawings.

B. Subsurface drainage as indicated on the Drawings.

1.02 CODES AND STANDARDS

A. Excavating, trenching, filling, backfilling, and grading work shall meet the applicable requirements of the Uniform Building Code and the standards and ordinances of state and local governing authorities.

1.03 SUBSURFACE SOIL CONDITIONS

A. The Owners' Geotechnical Exploration report is available for inspection by bidder or Contractor. The Contractor shall refer to the findings and recommendations of the Geotechnical Exploration report in planning and executing his work.

1.04 DEFINITIONS

A. Fill: All soil, rock, or soil-rock materials placed to raise the grades of the site or to backfill excavations.

B. Backfill: All soil, rock or soil-rock material used to fill excavations and trenches.

C. On-Site Material: Soil and/or rock material, which is obtained from the site.

D. Imported Material: Soil and/or rock material which is brought to the site from off-site areas.

E. Select Material: On-site and/or imported material which is approved by ENGEO as a specific-purpose fill.

F. Engineered Fill: Fill upon which ENGEO has made sufficient observations and tests to confirm that the fill has been placed and compacted in accordance with specifications and requirements.

G. Degree of Compaction or Relative Compaction: The ratio, expressed as a percentage, of the in-place dry density of the fill and backfill material as compacted in the field to the maximum dry density of the same material as determined by ASTM D-1557 or California 216 compaction test method.

H. Optimum Moisture: Water content, percentage by dry weight, corresponding to the maximum dry density as determined by ASTM D-1557.

I. ENGEO: The project geotechnical engineering consulting firm, its employees or its designated representatives.

J. Drawings: All documents, approved for construction, which describe the Work.

1.05 OBSERVATION AND TESTING

A. All site preparation, cutting and shaping, excavating, filling, and backfilling shall be carried out under the observation of ENGEO, employed and paid for by the Owners. ENGEO will perform appropriate field and laboratory tests to evaluate the suitability of fill material, the proper moisture content for compaction, and the degree of compaction achieved. Any fill that does not meet the specification requirements shall be removed and/or reworked until the requirements are satisfied.

B. Cutting and shaping, excavating, conditioning, filling, and compacting procedures require approval of ENGEO as they are performed. Any work found unsatisfactory or any work disturbed by subsequent operations before approval is granted shall be corrected in an approved manner as recommended by ENGEO.

C. Tests for compaction will be made in accordance with test procedures outlined in ASTM D-1557, as applicable. Field testing of soils or compacted fill shall conform with the applicable requirements of ASTM D-2922.

D. All authorized observation and testing will be paid for by the Owners.

1.06 SITE CONDITIONS

A. Excavating, filling, backfilling, and grading work shall not be performed during unfavorable weather conditions. When the work is interrupted by rain, excavating, filling, backfilling, and grading work shall not be resumed until the site and soil conditions are suitable.

B. Contractor shall take the necessary measures to prevent erosion of freshly filled, backfilled, and graded areas until such time as permanent drainage and erosion control measures have been installed.

PART 2 - PRODUCTS

2.01 GENERAL

A. Contractor shall furnish all materials, tools, equipment, facilities, and services as required for performing the required excavating, filling, backfilling, and grading work, and trenching and backfilling for utilities.

2.02 SOIL MATERIALS

A. Fill

1. Material to be used for engineered fill and backfill shall be free from organic matter and other deleterious substances, and of such quality that it will compact thoroughly without excessive voids when watered and rolled. Excavated on-site material will be considered suitable for engineered fill and backfill if it contains no more than 3 percent organic matter, is free of debris and other deleterious substances and conforms to the requirements specified above. Rocks of maximum dimension in excess of two-thirds of the lift thickness shall be removed from any fill material to the satisfaction of ENGEO.

2. Excavated earth material which is suitable for engineered fill or backfill, as determined by ENGEO, shall be conditioned for reuse and properly stockpiled as required for later filling and backfilling operations. Conditioning shall consist of spreading material in layers not to exceed 8 inches and raking free of debris and rubble. Rocks and aggregate exceeding the allowed largest dimension, and deleterious material shall be removed from the site and disposed off site in a legal manner.

3. ENGEO shall be immediately notified if potential hazardous materials or suspect soils exhibiting staining or odor are encountered. Work activities shall be discontinued within the area of potentially hazardous materials. ENGEO environmental personnel will conduct an assessment of the suspect hazardous material to determine the appropriate response and mitigation. Regulatory agencies may also be contacted to request concurrence and oversight. ENGEO will rely on the Owner, or a designated Owner's representative, to make necessary *notices to the appropriate regulatory agencies. The Owner may*

request ENGEO's assistance in notifying regulatory agencies, provided ENGEO receives Owner's written authorization to expand its scope of services.

4. ENGEO shall be notified at least 48 hours prior to the start of filling and backfilling operations so that it may evaluate samples of the material intended for use as fill and backfill. All materials to be used for filling and backfilling require the approval of ENGEO.

B. Import Material: Where conditions require the importation of fill material, the material shall be an inert, nonexpansive soil or soil-rock material free of organic matter and meeting the following requirements unless otherwise approved by ENGEO.

Gradation (ASTM D-421):	Sieve Size	Percent Passing
	2-inch	100
	#200	15 - 70
Plasticity (ASTM D-4318):	Liquid Limit	Plasticity Index
	< 30	< 12
Swell Potential (ASTM D-4546B): (at optimum moisture)	Percent Heave	Swell Pressure
	< 2 percent	< 300 psf
Resistance Value (ASTM D-2844):	Minimum 25	
Organic Content (ASTM D-2974):	Less than 2 percent	

A sample of the proposed import material should be submitted to ENGEO for evaluation prior to delivery at the site.

2.03 SAND

A. Sand for sand cushion under slabs and for bedding of pipe in utility trenches shall be a clean and graded, washed sand, free from clay or organic material, suitable for the intended purpose with 90 to 100 percent passing a No. 4 U.S. Standard Sieve, not more than 5 percent passing a No. 200 U.S. Standard Sieve, and generally conforming to ASTM C33 for fine aggregate.

2.04 AGGREGATE DRAINAGE FILL

A. Aggregate drainage fill under concrete slabs and paving shall consist of broken stone, crushed or uncrushed gravel, clean quarry waste, or a combination thereof. The aggregate shall be free from fines, vegetable matter, loam, volcanic tuff, and other deleterious substances. It shall be of such quality that the absorption of water in a saturated surface dry condition does not exceed 3 percent of the oven dry weight of the samples.

B. Aggregate drainage fill shall be of such size that the percentage composition by dry weight as determined by laboratory sieves (U. S. Series) will conform to the following grading:

Sieve Size	Percentage Passing Sieve
1½-inches	100
1-inch	90 - 100
#4	0 - 5

2.05 SUBDRAINS

A. Perforated subdrain pipe of the required diameter shall be installed as shown on the drawings. The pipe(s) shall also conform to these specifications unless otherwise specified by ENGEO in the field.

Subdrain pipe shall be manufactured in accordance with one of the following requirements:

Design depths less than 30 feet

- Perforated ABS Solid Wall SDR 35 (ASTM D-2751)
- Perforated PVC Solid Wall SDR 35 (ASTM D-3034)
- Perforated PVC A-2000 (ASTM F949)
- Perforated Corrugated HDPE double-wall (AASHTO M-252 or M-294, Caltrans Type S, 50 psi minimum stiffness)

Design depths less than 50 feet

- Perforated PVC SDR 23.5 Solid Wall (ASTM D-3034)
- Perforated Sch. 40 PVC Solid Wall (ASTM-1785)
- Perforated ABS SDR 23.5 Solid Wall (ASTM D-2751)
- Perforated ABS DWV/Sch. 40 (ASTM D-2661 and D-1527)
- Perforated Corrugated HDPE double-wall (AASHTO M-252 or M-294, Caltrans Type S, 70 psi minimum stiffness)

Design depths less than 70 feet

- Perforated ABS Solid Wall SDR 15.3 (ASTM D-2751)
- Perforated Sch. 80 PVC (ASTM D-1785)

- Perforated Corrugated Aluminum (ASTM B-745)

B. Permeable Material (Class 2): Class 2 permeable material for filling trenches under, around, and over subdrains, behind building and retaining walls, and for pervious blankets shall consist of clean, coarse sand and gravel or crushed stone, conforming to the following grading requirements:

Sieve Size	Percentage Passing Sieve
1-inch	100
¾-inch	90 - 100
⅜-inch	40 - 100
#4	25 - 40
#8	18 - 33
#30	5 - 15
#50	0 - 7
#200	0 - 3

C. Filter Fabric: All filter fabric shall meet the following Minimum Average Roll Values unless otherwise specified by ENGEO.

Grab Strength (ASTM D-4632) ....180 lbs
Mass Per Unit Area (ASTM D-4751) ....6 oz/yd^2
Apparent Opening Size (ASTM D-4751) ....70-100 U.S. Std. Sieve
Flow Rate (ASTM D-4491) ....80 gal/min/ft^2
Puncture Strength (ASTM D-4833) ....80 lbs

D. Vapor Retarder: Vapor Retarders shall consist of PVC, LDPE or HDPE impermeable sheeting at least 10 mils thick.

2.06 PERMEABLE MATERIAL (Class 1; Type A)

A. Class 1 permeable material to be used in conjunction with filter fabric for backfilling of subdrain excavations shall conform to the following grading requirements:

Sieve Size	Percentage Passing Sieve
¾-inch	100
½-inch	95 - 100
⅜-inch	70 - 100
#4	0 - 55
#8	0 - 10
#200	0 - 3

PART 3 - EXECUTION

3.01 STAKING AND GRADES

A. Contractor shall lay out all his work, establish all necessary markers, bench marks, grading stakes, and other stakes as required to achieve design grades.

3.02 EXISTING UTILITIES

A. Contractor shall verify the location and depth (elevation) of all existing utilities and services before performing any excavation work.

3.03 EXCAVATION

A. Contractor shall perform excavating as indicated and required for concrete footings, drilled piers, foundations, floor slabs, concrete walks, and site leveling and grading, and provide shoring, bracing, underpinning, cribbing, pumping, and planking as required. The bottoms of excavations shall be firm undisturbed earth, clean and free from loose material, debris, and foreign matter.

B. Excavations shall be kept free from water at all times. Adequate dewatering equipment shall be maintained at the site to handle emergency situations until concrete or backfill is placed.

C. Unauthorized excavations for footings shall be filled with concrete to required elevations, unless other methods of filling are authorized by ENGEO.

D. Excavated earth material which is suitable for engineered fill or backfill, as determined by ENGEO, shall be conditioned for reuse and properly stockpiled for later filling and backfilling operations as specified under Section 2.02, "Soil Materials."

E. Abandoned sewers, piping, and other utilities encountered during excavating shall be removed and the resulting excavations shall be backfilled with engineered fill as required by ENGEO.

F. Any active utility lines encountered shall be reported immediately to the Owner's Representative and authorities involved. The Owner and proper authorities shall be permitted free access to take the measures deemed necessary to repair, relocate, or remove the obstruction as determined by the responsible authority or Owner's Representative.

3.04 SUBGRADE PREPARATION

A. All brush and other rubbish, as well as trees and root systems not marked for saving, shall be removed from the site and legally disposed of.

B. Any existing structures, foundations, underground storage tanks, or debris must be removed from the site prior to any building, grading, or fill operations. Septic tanks, including all drain fields and other lines, if encountered, must be totally removed. The resulting depressions shall be properly prepared and filled to the satisfaction of ENGEO.

C. Vegetation and organic topsoil shall be removed from the surface upon which the fill is to be placed and either removed and legally disposed of or stockpiled for later use in approved landscape areas. The surface shall then be scarified to a depth of at least eight inches until the surface is free from ruts, hummocks, or other uneven features which would tend to prevent uniform compaction by the equipment to be used.

D. After the foundation for the fill has been cleared and scarified, it shall be made uniform and free from large clods. The proper moisture content must be obtained by adding water or aerating. The foundation for the fill shall be compacted at the proper moisture content to a relative compaction as specified herein.

3.05 ENGINEERED FILL

A. Select Material: Fill material shall be "Select" or "Imported Material" as previously specified.

B. Placing and Compacting: Engineered fill shall be constructed by approved and accepted methods. Fill material shall be spread in uniform lifts not exceeding 8 inches in uncompacted thickness. Each layer shall be spread evenly, and thoroughly blade-mixed to obtain uniformity of material. Fill material which does not contain sufficient moisture as specified by ENGEO shall be sprinkled with water; if it contains excess moisture it shall be aerated or blended with drier material to achieve the proper water content. Select material and water shall then be thoroughly mixed before being compacted.

C. Unless otherwise specified in the Geotechnical Exploration report, each layer of spread select material shall be compacted to at least 90 percent relative compaction at a moisture content of at least three percentage points above the optimum moisture content. Minimum compaction in all keyways shall be a minimum of 95 percent with a minimum moisture content of at least 1 percentage point above optimum.

D. Unless otherwise specified in the Geotechnical Exploration report or otherwise required by the local authorities, the upper 6 inches of engineered fill in areas to receive pavement shall be compacted to at least 95 percent relative compaction with a minimum moisture content of at least 3 percentage points above optimum.

E. Testing and Observation of Fill: The work shall consist of field observation and testing to determine that each layer has been compacted to the required density and that the required moisture is being obtained. Any layer or portion of a layer that does not attain the compaction required shall be reworked until the required density is obtained.

F. Compaction: Compaction shall be by sheepsfoot rollers, multiple-wheel steel or pneumatic-tired rollers or other types of acceptable compaction equipment. Rollers shall be of such design that they will be able to compact the fill to the specified compaction. Rolling shall be accomplished while the fill material is within the specified moisture content range. Rolling of each layer must be continuous so that the required compaction may be obtained uniformly throughout each layer.

G. Fill slopes shall be constructed by overfilling the design slopes and later cutting back the slopes to the design grades. No loose soil will be permitted on the faces of the finished slopes.

H. Strippings and topsoil shall be stockpiled as approved by Owner, then placed in accordance with ENGEO's recommendations to a minimum thickness of 6 inches and a maximum thickness of 12 inches over exposed open space cut slopes which are 3:1 or flatter, and track walked to the satisfaction of ENGEO.

I. Final Prepared Subgrade: Finish blading and smoothing shall be performed as necessary to produce the required density, with a uniform surface, smooth and true to grade.

3.06 BACKFILLING

A. Backfill shall not be placed against footings, building walls, or other structures until approved by ENGEO.

B. Backfill material shall be Select Material as specified for engineered fill.

C. Backfill shall be placed in 6-inch layers, leveled, rammed, and tamped in place. Each layer shall be compacted with suitable compaction equipment to 90 percent relative compaction at a moisture content of at least 3 percent above optimum.

3.07 TRENCHING AND BACKFILLING FOR UTILITIES

A. Trenching:

1. Trenching shall include the removal of material and obstructions, the installation and removal of sheeting and bracing and the control of water as necessary to provide the required utilities and services.

2. Trenches shall be excavated to the lines, grades, and dimensions indicated on the Drawings. Maximum allowable trench width shall be the outside diameter of the pipe plus 24 inches, inclusive of any trench bracing.

3. When the trench bottom is a soft or unstable material as determined by ENGEO, it shall be made firm and solid by removing said unstable material to a sufficient depth and replacing it with on-site material compacted to 90 percent minimum relative compaction.

4. Where water is encountered in the trench, the contractor must provide materials necessary to drain the water and stabilize the bed.

B. Backfilling:

1. Trenches must be backfilled within 2 days of excavation to minimize desiccation.

2. Bedding material shall be sand and shall not extend more than 6 inches above any utility lines.

3. Backfill material shall be select material.

4. Trenches shall be backfilled as indicated or required and compacted with suitable equipment to 90 percent minimum relative compaction at the required moisture content.

3.08 SUBDRAINS

A. Trenches for subdrain pipe shall be excavated to a minimum width equal to the outside diameter of the pipe plus at least 12 inches and to a depth of approximately 2 inches below the grade established for the invert of the pipe, or as indicated on the Drawings.

B. The space below the pipe invert shall be filled with a layer of Class 2 permeable material, upon which the pipe shall be laid with perforations down. Sections shall be joined as recommended by the pipe manufacturer.

C. Rocks, bricks, broken concrete, or other hard material shall not be used to give intermediate support to pipes. Large stones or other hard objects shall not be left in contact with the pipes.

D. Excavations for subdrains shall be filled as required to fill voids and prevent settlement without damaging the subdrain pipe. Alternatively, excavations for subdrains may be filled with Class 1 permeable material (as defined in Section 2.06) wrapped in Filter Fabric (as defined in Section 2.05).

3.09 AGGREGATE DRAINAGE FILL

A. ENGEO shall approve finished subgrades before aggregate drainage fill is installed.

B. Pipes, drains, conduits, and any other mechanical or electrical installations shall be in place before any aggregate drainage fill is placed. Backfill at walls to elevation of drainage fill shall be in place and compacted.

C. Aggregate drainage fill under slabs and concrete paving shall be the minimum uniform thickness after compaction of dimensions indicated on Drawings. Where not indicated, minimum thickness after compaction shall be 4 inches.

D. Aggregate drainage fill shall be rolled to form a well-compacted bed.

E. The finished aggregate drainage fill must be observed and approved by ENGEO before proceeding with any subsequent construction over the compacted base or fill.

3.10 AND CUSHION

A. A sand cushion shall be placed over the vapor retarder membrane under concrete slabs on grade. Sand cushion shall be placed in uniform thickness as indicated on the Drawings. Where not indicated, the thickness shall be 2 inches.

3.11 FINISH GRADING

A. All areas must be finish graded to elevations and grades indicated on the Drawings. In areas to receive topsoil and landscape planting, finish grading shall be performed to a uniform 6 inches below the grades and elevations indicated on the Drawings, and brought to final grade with topsoil.

3.12 DISPOSAL OF WASTE MATERIALS

A. Excess earth materials and debris shall be removed from the site and disposed of in a legal manner. Location of dump site and length of haul are the Contractor's responsibility.

PART II - GEOGRID SOIL REINFORCEMENT

1 DESCRIPTION:

Work shall consist of furnishing geogrid soil reinforcement for use in construction of reinforced soil slopes and retention systems.

2. GEOGRID MATERIAL:

2.1 The specific geogrid material shall be preapproved by ENGEO.

2.2 The geogrid shall be a regular network of integrally connected polymer tensile elements with aperture geometry sufficient to permit significant mechanical interlock with the surrounding soil or rock. The geogrid structure shall be dimensionally stable and able to retain its geometry under construction stresses and shall have high resistance to damage during construction, to ultraviolet degradation, and to all forms of chemical and biological degradation encountered in the soil being reinforced.

2.3 The geogrids shall have an Allowable Strength (T_a) and Pullout Resistance, for the soil type(s) indicated, as listed in Table I.

2.4 Certifications: The Contractor shall submit a manufacturer's certification that the geogrids supplied meet the respective index criteria set when geogrid was approved by ENGEO, measured in full accordance with all test methods and standards specified. In case of dispute over validity of values, the Contractor will supply test data from an ENGEO-approved laboratory to support the certified values submitted.

3. CONSTRUCTION:

3.1 Delivery, Storage, and Handling: Contractor shall check the geogrid upon delivery to ensure that the proper material has been received. During all periods of shipment and storage, the geogrid shall be protected from temperatures greater than 140 °F, mud, dirt, dust, and debris. Manufacturer's recommendations in regard to protection from direct sunlight must also be followed. At the time of installation, the geogrid will be rejected if it has defects, tears, punctures, flaws, deterioration, or damage incurred during manufacture, transportation, or storage. If approved by ENGEO, torn or punctured sections may be repaired by placing a patch over the damaged area. Any geogrid damaged during storage or installation shall be replaced by the Contractor at no additional cost to the owner.

3.2 On-Site Representative: Geogrid material suppliers shall provide a qualified and experienced representative on site at the initiation of the project, for a minimum of three days, to assist the Contractor and ENGEO personnel at the start of construction. If there is more than one slope on a project, this criterion will apply to construction of the initial slope only. The representative shall also be available on an as-needed basis, as requested by ENGEO, during construction of the remaining slope(s).

3.3 Geogrid reinforcement may be joined with mechanical connections or overlaps as recommended and approved by the Manufacturer. Joints shall not be placed within 6 feet of the slope face, within 4 feet below top of slope, nor horizontally or vertically adjacent to another joint.

3.4 Geogrid Placement: The geogrid reinforcement shall be installed in accordance with the manufacturer's recommendations. The geogrid reinforcement shall be placed within the layers of the compacted soil as shown on the plans or as directed.

The geogrid reinforcement shall be placed in continuous longitudinal strips in the direction of main reinforcement. However, if the Contractor is unable to complete a required length with a single continuous length of geogrid, a joint may be made with the Manufacturer's approval. Only one joint per length of geogrid shall be allowed. This joint shall be made for the full width of the strip by using a similar material with similar strength. Joints in geogrid reinforcement shall be pulled and held taut during fill placement.

Adjacent strips, in the case of 100 percent coverage in plan view, need not be overlapped. The minimum horizontal coverage is 50 percent, with horizontal spacings between reinforcement no greater than 40 inches. Horizontal coverage of less than 100 percent shall not be allowed unless specifically detailed in the construction drawings.

Adjacent rolls of geogrid reinforcement shall be overlapped or mechanically connected where exposed in a wrap around face system, as applicable.

The Contractor may place only that amount of geogrid reinforcement required for immediately pending work to prevent undue damage. After a layer of geogrid reinforcement has been placed, the next succeeding layer of soil shall be placed and compacted as appropriate. After the specified soil layer has been placed, the next geogrid reinforcement layer shall be installed. The process shall be repeated for each subsequent layer of geogrid reinforcement and soil.

Geogrid reinforcement shall be placed to lay flat and pulled tight prior to backfilling. After a layer of geogrid reinforcement has been placed, suitable means, such as pins or small piles of soil, shall be used to hold the geogrid reinforcement in position until the subsequent soil layer can be placed.

Under no circumstances shall a track-type vehicle be allowed on the geogrid reinforcement before at least six inches of soil have been placed. Turning of tracked vehicles should be kept to a minimum to prevent tracks from displacing the fill and the geogrid reinforcement. If approved by the Manufacturer, rubber-tired equipment may pass over the geosynthetic reinforcement at slow speeds, less than 10 mph. Sudden braking and sharp turning shall be avoided.

During construction, the surface of the fill should be kept approximately horizontal. Geogrid reinforcement shall be placed directly on the compacted horizontal fill surface. Geogrid reinforcements are to be placed within three inches of the design elevations and extend the length as shown on the elevation view unless otherwise directed by ENGEO. Correct orientation of the geogrid reinforcement shall be verified by ENGEO.

Table I
Allowable Geogrid Strength
With Various Soil Types
For Geosynthetic Reinforcement In
Mechanically Stabilized Earth Slopes

(Geogrid Pullout Resistance and Allowable Strengths vary with reinforced backfill used due to soil anchorage and site damage factors. Guidelines are provided below.)

SOIL TYPE	MINIMUM ALLOWABLE STRENGTH, T_a (lb/ft)*		
	GEOGRID Type I	GEOGRID Type II	GEOGRID Type III
A. Gravels, sandy gravels, and gravel-sand-silt mixtures (GW, GP, GC, GM & SP)**	2400	4800	7200
B. Well graded sands, gravelly sands, and sand-silt mixtures (SW & SM)**	2000	4000	6000
C. Silts, very fine sands, clayey sands and clayey silts (SC & ML)**	1000	2000	3000
D. Gravelly clays, sandy clays, silty clays, and lean clays (CL)**	1600	3200	4800

* All partial Factors of Safety for reduction of design strength are included in listed values. Additional factors of safety may be required to further reduce these design strengths based on site conditions.

** Unified Soil Classifications.

PART III - GEOTEXTILE SOIL REINFORCEMENT

1. DESCRIPTION:

   Work shall consist of furnishing geotextile soil reinforcement for use in construction of reinforced soil slopes.

2. GEOTEXTILE MATERIAL:

   2.1 The specific geotextile material and supplier shall be preapproved by ENGEO.

   2.2 The geotextile shall have a high tensile modulus and shall have high resistance to damage during construction, to ultraviolet degradation, and to all forms of chemical and biological degradation encountered in the soil being reinforced.

   2.3 The geotextiles shall have an Allowable Strength (Ta) and Pullout Resistance, for the soil type(s) indicated as listed in Table II.

   2.4 Certification: The Contractor shall submit a manufacturer's certification that the geotextiles supplied meet the respective index criteria set when geotextile was approved by ENGEO, measured in full accordance with all test methods and standards specified. In case of dispute over validity of values, the Contractor will supply the data from an ENGEO-approved laboratory to support the certified values submitted.

3. CONSTRUCTION:

   3.1 Delivery, Storage and Handling: Contractor shall check the geotextile upon delivery to ensure that the proper material has been received. During all periods of shipment and storage, the geotextile shall be protected from temperatures greater than 140 °F, mud, dirt, dust, and debris. Manufacturer's recommendations in regard to protection from direct sunlight must also be followed. At the time of installation, the geotextile will be rejected if it has defects, tears, punctures, flaws, deterioration, or damage incurred during manufacture, transportation, or storage. If approved by ENGEO, torn or punctured sections may be repaired by placing a patch over the damaged area. Any geotextile damaged during storage or installation shall be replaced by the Contractor at no additional cost to the owner.

   3.2 On-Site Representative: Geotextile material suppliers shall provide a qualified and experienced representative on site at the initiation of the project, for a minimum of three days, to assist the Contractor and ENGEO personnel at the start of construction. If there is more than one slope on a project, this criterion will apply to construction of the initial slope only. The representative shall also be available on an as-needed basis, as requested by ENGEO, during construction of the remaining slope(s).

3.3 Geotextile Placement: The geotextile reinforcement shall be installed in accordance with the manufacturer's recommendations. The geotextile reinforcement shall be placed within the layers of the compacted soil as shown on the plans or as directed.

The geotextile reinforcement shall be placed in continuous longitudinal strips in the direction of main reinforcement. Joints shall not be used with geotextiles.

Adjacent strips, in the case of 100 percent coverage in plan view, need not be overlapped. The minimum horizontal coverage is 50 percent, with horizontal spacings between reinforcement no greater than 40 inches. Horizontal coverage of less than 100 percent shall not be allowed unless specifically detailed in the construction drawings.

Adjacent rolls of geotextile reinforcement shall be overlapped or mechanically connected where exposed in a wrap around face system, as applicable.

The Contractor may place only that amount of geotextile reinforcement required for immediately pending work to prevent undue damage. After a layer of geotextile reinforcement has been placed, the succeeding layer of soil shall be placed and compacted as appropriate. After the specified soil layer has been placed, the next geotextile reinforcement layer shall be installed. The process shall be repeated for each subsequent layer of geotextile reinforcement and soil.

Geosynthetic reinforcement shall be placed to lay flat and be pulled tight prior to backfilling. After a layer of geotextile reinforcement has been placed, suitable means, such as pins or small piles of soil, shall be used to hold the geotextile reinforcement in position until the subsequent soil layer can be placed.

Under no circumstances shall a track-type vehicle be allowed on the geotextile reinforcement before at least six inches of soil has been placed. Turning of tracked vehicles should be kept to a minimum to prevent tracks from displacing the fill and the geotextile reinforcement. If approved by the Manufacturer, rubber-tired equipment may pass over the geotextile reinforcement as slow speeds, less than 10 mph. Sudden braking and sharp turning shall be avoided.

During construction, the surface of the fill should be kept approximately horizontal. Geotextile reinforcement shall be placed directly on the compacted horizontal fill surface. Geotextile reinforcements are to be placed within three inches of the design elevations and extend the length as shown on the elevation view unless otherwise directed by ENGEO. Correct orientation of the geotextile reinforcement shall be verified by ENGEO.

Table II
Allowable Geotextile Strength
With Various Soil Types
For Geosynthetic Reinforcement In
Mechanically Stabilized Earth Slopes

(Geotextile Pullout Resistance and Allowable Strengths vary with reinforced backfill used due to soil anchorage and site damage factors. Guidelines are provided below.)

SOIL TYPE	MINIMUM ALLOWABLE STRENGTH, Ta (lb/ft)*		
	GEOTEXTILE Type I	GEOTEXTILE Type II	GEOTEXTILE Type III
A. Gravels, sandy gravels, and gravel-sand-silt mixtures (GW, GP, GC, GM & SP)**	2400	4800	7200
B. Well graded sands, gravelly sands, and sand-silt mixtures (SW & SM)**	2000	4000	6000
C. Silts, very fine sands, clayey sands and clayey silts (SC & ML)**	1000	2000	3000
D. Gravelly clays, sandy clays, silty clays, and lean clays (CL)**	1600	3200	4800

*All partial Factors of Safety for reduction of design strength are included in listed values. Additional factors of safety may be required to further reduce these design strengths based on site conditions.
**Unified Soil Classifications.

PART IV - EROSION CONTROL MAT OR BLANKET

1. DESCRIPTION:

Work shall consist of furnishing and placing a synthetic erosion control mat and/or degradable erosion control blanket for slope face protection and lining of runoff channels.

2. EROSION CONTROL MATERIALS:

2.1 The specific erosion control material and supplier shall be pre-approved by ENGEO.

2.2 Certification: The Contractor shall submit a manufacturer's certification that the erosion mat/blanket supplied meets the criteria specified when the material was approved by ENGEO. The manufacturer's certification shall include a submittal package of documented test results that confirm the property values. In case of a dispute over validity of values, the Contractor will supply property test data from an ENGEO-approved laboratory, to support the certified values submitted. Minimum average roll values, per ASTM D 4759, shall be used for conformance determinations.

3. CONSTRUCTION:

3.1 Delivery, Storage, and Handling: Contractor shall check the erosion control material upon delivery to ensure that the proper material has been received. During all periods of shipment and storage, the erosion mat shall be protected from temperatures greater than 140 °F, mud, dirt, and debris. Manufacturer's recommendations in regard to protection from direct sunlight must also be followed. At the time of installation, the erosion mat/blanket shall be rejected if it has defects, tears, punctures, flaws, deterioration, or damage incurred during manufacture, transportation, or storage. If approved by ENGEO, torn or punctured sections may be removed by cutting OUT a section of the mat. The remaining ends should be overlapped and secured with ground anchors. Any erosion mat/blanket damaged during storage or installation shall be replaced by the Contractor at no additional cost to the Owner.

3.2 On-Site Representative: Erosion control material suppliers shall provide a qualified and experienced representative on site, for a minimum of one day, to assist the Contractor and ENGEO personnel at the start of construction. If there is more than one slope on a project, this criteria will apply to construction of the initial slope only. The representative shall be available on an as-needed basis, as requested by ENGEO, during construction of the remaining slope(s).

3.3 Placement: The erosion control material shall be placed and anchored on a smooth graded, firm surface approved by the Engineer. Anchoring terminal ends of the erosion control material shall be accomplished through use of key trenches. The material in the trenches shall be anchored to the soil on maximum 1½ foot centers. Topsoil, if required by construction drawings, placed over final grade prior to installation of the erosion control material shall be limited to a depth not exceeding 3 inches.

3.4 Erosion control material shall be anchored, overlapped, and otherwise constructed to ensure performance until vegetation is well established. Anchors shall be as designated on the construction drawings, with a minimum of 12 inches length, and shall be spaced as designated on the construction drawings, with a maximum spacing of 4 feet.

3.5 Soil Filling: If noted on the construction drawings, the erosion control mat shall be filled with a fine grained topsoil, as recommended by the manufacturer. Soil shall be lightly raked or brushed on/into the mat to fill the mat voids or to a maximum depth of 1 inch.

PART V - GEOSYNTHETIC DRAINAGE COMPOSITE

1. DESCRIPTION:

Work shall consist of furnishing and placing a geosynthetic drainage system as a subsurface drainage medium for reinforced soil slopes.

2. DRAINAGE COMPOSITE MATERIALS:

2.1 The specific drainage composite material and supplier shall be preapproved by ENGEO.

2.2 The drain shall be of composite construction consisting of a supporting structure or drainage core material surrounded by a geotextile. The geotextile shall encapsulate the drainage core and prevent random soil intrusion into the drainage structure. The drainage core material shall consist of a three dimensional polymeric material with a structure that permits flow along the core laterally. The core structure shall also be constructed to permit flow regardless of the water inlet surface. The drainage core shall provide support to the geotextile. The fabric shall meet the minimum property requirements for filter fabric listed in Section 2.05C of the Guide Earthwork Specifications.

2.3 A geotextile flap shall be provided along all drainage core edges. This flap shall be of sufficient width for sealing the geotextile to the adjacent drainage structure edge to prevent soil intrusion into the structure during and after installation. The geotextile shall cover the full length of the core.

2.4 The geocomposite core shall be furnished with an approved method of constructing and connecting with outlet pipes or weepholes as shown on the plans. Any fittings shall allow entry of water from the core but prevent intrusion of backfill material into the core material.

2.5 Certification and Acceptance: The Contractor shall submit a manufacturer's certification that the geosynthetic drainage composite meets the design properties and respective index criteria measured in full accordance with all test methods and standards specified. The manufacturer's certification shall include a submittal package of documented test results that confirm the design values. In case of dispute over validity of design values, the Contractor will supply design property test data from an ENGEO-approved laboratory, to support the certified values submitted. Minimum average roll values, per ASTM D 4759, shall be used for determining conformance.

3. CONSTRUCTION:

3.1 Delivery, Storage, and Handling: Contractor shall check the geosynthetic drainage composite upon delivery to ensure that the proper material has been received. During all periods of shipment and storage, the geosynthetic drainage composite shall be protected from temperatures greater than 140 °F, mud, dirt, and debris. Manufacturer's recommendations in regards to protection from direct sunlight must also be followed. At the time of installation, the geosynthetic drainage composite shall be rejected if it has defects, tears, punctures, flaws, deterioration, or damage incurred during manufacture, transportation, or storage. If approved by ENGEO, torn or punctured sections may be removed or repaired. Any geosynthetic drainage composite damaged during storage or installation shall be replaced by the Contractor at no additional cost to the Owner.

3.2 On-Site Representative: Geosynthetic drainage composite material suppliers shall provide a qualified and experienced representative on site, for a minimum of one half day, to assist the Contractor and ENGEO personnel at the start of construction with directions on the use of drainage composite. If there is more than one application on a project, this criterion will apply to construction of the initial application only. The representative shall also be available on an as-needed basis, as requested by ENGEO, during construction of the remaining applications.

3.3 Placement: The soil surface against which the geosynthetic drainage composite is to be placed shall be free of debris and inordinate irregularities that will prevent intimate contact between the soil surface and the drain.

3.4 Seams: Edge seams shall be formed by utilizing the flap of the geotextile extending from the geocomposite's edge and lapping over the top of the fabric of the adjacent course. The fabric flap shall be securely fastened to the adjacent fabric by means of plastic tape or non-water-soluble construction adhesive, as recommended by the supplier. Where vertical splices are necessary at the end of a geocomposite roll or panel, an 8-inch-wide continuous strip of geotextile may be placed, centering over the seam and continuously fastened on both sides with plastic tape or non-water-soluble construction adhesive. As an alternative, rolls of geocomposite drain material may be joined together by turning back the fabric at the roll edges and interlocking the cuspidations approximately 2 inches. For overlapping in this manner, the fabric shall be lapped and tightly taped beyond the seam with tape or adhesive. Interlocking of the core shall always be made with the upstream edge on top in the direction of water flow. To prevent soil intrusion, all exposed edges of the geocomposite drainage core edge must be covered. Alternatively, a 12-inch-wide strip of fabric may be utilized in the same manner, fastening it to the exposed fabric 8 inches in from the edge and folding the remaining flap over the core edge.

3.5 Soil Fill Placement: Structural backfill shall be placed immediately over the geocomposite drain. Care shall be taken during the backfill operation not to damage the geotextile surface of the drain. Care shall also be taken to avoid excessive settlement of the backfill material. The geocomposite drain, once installed, shall not be exposed for more than seven days prior to backfilling.