CORNERSTONE EARTH GROUP

Type of Services	**Geotechnical Investigation**
Project Name	**Sanchez Bypass and Neighborhood Sewer Rehabilitation Project**
Location	**Sanchez Avenue** **Burlingame, California**
Client	**Hatch Mott McDonald**
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CORNERSTONE EARTH GROUP

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Type of Services	**Geotechnical Investigation**
Project Name	**Sanchez Bypass and Neighborhood Sewer Rehabilitation Project**
Location	**Sanchez Avenue** **Burlingame, California**

SECTION 1: INTRODUCTION

This geotechnical report was prepared for the sole use of Hatch Mott McDonald for the planned Sanchez Bypass and Neighborhood Sewer Rehabilitation Project that will be located along portions of Sanchez Avenue and intersecting streets, Paloma Avenue and others, in Burlingame, California. In addition, recommendations for the repair of a short section of sewer at Burlway and Bayshore Highway are included in this report. The location of the sewer rehabilitation projects are shown on the Vicinity Map, Figure 1.

For our use, we were provided with preliminary plans titled "Sanchez Bypass and Neighborhood Sewer Rehabilitation Project Phase II", prepared by Hatch Mott McDonald and dated December 15, 2011.

1.1 PROJECT DESCRIPTION

The Phase II project includes the Sanchez Bypass and Neighborhood Sewer Rehabilitation improvements. The project will generally consist of replacing or adding sanitary sewer mains and laterals. In some cases the existing pipes will be up-sized or lined.

Table 1 of this report summarizes the sewer rehabilitation sections and Figures 2A and 2B shows the sewer rehabilitation section locations. Six of the sewer rehabilitation sections are planned to be constructed using open cut trenches. Two of the sewer rehabilitation sections are planned to be constructed using the horizontal directional drilling method. Six sewer rehabilitation sections are planned to be improved using the pipe bursting and replacement method, and three sewer rehabilitation sections are planned to be improved using the cast-in-place polymer pipe method. We also understand that trenchless methods are likely to be used for the El Camino Real crossing at Sanchez Avenue.

At this time, the type of construction has not been chosen for the Burlway Road and Bayshore Highway rehabilitation section. This sewer section was constructed over soft bay mud soils (soft, compressible clays) and has settled since being constructed. We anticipate that this section will be improved by open cut trenching or some type of trenchless construction.

Table 1. Sewer Rehabilitation Sections Summary

Pipe Section	Station		Pipe Length (feet)	Pipe Dia.[1.] (inches)	Pipe Type[2.]	Depth (feet)	Comments
	From	To					
Open Cut Sections							
OC1[3.]	207+79	213+61	582	18	PVC	16-11	Along Sanchez Ave from Paloma Ave to Chula Vista Ave
OC2	213+61	216+69	308	15	PVC	11-10	Along Sanchez Ave from Chula Vista Ave to California Drive
OC3	410+00	414+00	414	8	PVC	18-5	Along Paloma Ave to Sanchez
OC4	430+00	433+08	308	8	PVC	15-4	Along Laguna Ave
OC5	440+00	443+08	308	18	PVC	13-5	SE from Sanchez between Laguna Ave and Chula Vista Ave
OC6	--	--	220	NS	NS	7-8	Burlway Road to Bayshore Highway
Horizontal Directionally-Drilled Sections							
HDD1	400+00	401+64	164	8	HDPE	7-6	In utility ROW
HDD2	420+00	421+68	168	8	HDPE	6-16	In utility ROW
Pipe Burst Sections							
PB1	300+00	303+59	359	NS (6)	NS (VCP)	3	
PB2	401+64	404+50	286	8 (6)	HDPE (VCP)	6-5	
PB3	421+68	423+49	181	8 (6)	HDPE (VCP)	6-5	
PB4	450+00	454+32	432	NS (NS)	NS (NS)	6?	Sht 18 Between Capuchino and El Camino toward Sanchez
PB4	460+00	466+48	648	8 (8)	HDPE VCP	7	
PB5	470+00	472+08	208	10 (10)	HDPE (VCP)	8-6	Between Paloma Ave and Laguna Ave toward Sanchez
PB6	480+33	482+24	191	8 (8)	HDPE (VCP)	9-6	Between Laguna Ave and Chula Vista Ave toward Sanchez Ave

Table 1. Sewer Rehabilitation Sections Summary (continued)

Cast-in-Place Polymer Pipe							
CP1	303+59	305+78	219	(10)	(VCP)	5	
CP2	307+32	308+94	162	(10)	(VCP)	5-6	
CP3	NS	NS	NS	NS	NS	NS	Outfall sewer section.

Table notes:
[1] ()' indicate existing pipe diameter.
[2] ()'s indicate existing pipe type.
[3] Reference identification for the different sewer rehabilitation sections.
[4] NS – not shown.

1.2 SCOPE OF SERVICES

Our scope of services was presented in our proposal dated December 6, 2011 and consisted of field and laboratory programs to evaluate physical and engineering properties of the subsurface soils, engineering analysis to prepare recommendations for pipe design and construction. Brief descriptions of our exploration and laboratory programs are presented below.

1.3 EXPLORATION PROGRAM

Field exploration consisted of seven borings drilled on January 23, 2012 and February 10, 2012 with truck-mounted hollow-stem auger drilling equipment and three borings drilled on January 26, 2012 with portable solid-stem auger drilling equipment. The borings were drilled to depths of approximately 14 to 25 feet. The approximate locations of our exploratory borings are shown on the Site Plan, Figures 2A and 2B. Details regarding our field program are included in Appendix A.

The borings were backfilled with cement grout in accordance with local requirements. Exploration permits were obtained prior to conducting the field investigation, as required by local jurisdictions.

1.4 LABORATORY TESTING PROGRAM

In addition to visual classification of samples, the laboratory program focused on obtaining data to support the potential sanitary sewer improvement methods, and to provide information regarding the subsurface conditions to subcontractors. Testing included moisture contents, dry densities, triaxial strength tests, and a Plasticity Index test. Details regarding our laboratory program are included in Appendix B.

1.5 ENVIRONMENTAL SERVICES

Environmental services were not requested for this project. If environmental concerns are determined to be present during future evaluations, the project environmental consultant should review our geotechnical recommendations for compatibility with the environmental concerns.

SECTION 2: REGIONAL SETTING

2.1 REGIONAL GEOLOGY

The San Francisco peninsula is a relatively narrow band of rock at the north end of the Santa Cruz Mountains separating the Pacific Ocean from San Francisco Bay. This represents one mountain range in a series of northwesterly-aligned mountains forming the Coast Ranges geomorphic province of California that stretches from the Oregon border nearly to Point Conception. In the San Francisco Bay area, most of the Coast Ranges have developed on a basement of tectonically mixed Cretaceous- and Jurassic-age (70- to 200-million years old) rocks of the Franciscan Complex. Locally these basement rocks are capped by younger sedimentary and volcanic rocks. Most of the Coast Ranges are covered by still younger surficial deposits that reflect geologic conditions of the last million years or so.

Movement on the many splays within the San Andreas Fault system has produced the dominant northwest-oriented structural and topographic trend seen throughout the Coast Ranges today. This trend reflects the boundary between two of the Earth's major tectonic plates: the North American plate to the east and the Pacific plate to the west. The San Andreas Fault system is about 40 miles wide in the Bay area and extends from the San Gregorio Fault near the coastline to the Coast Ranges-Central Valley blind thrust at the western edge of the Great Central Valley as shown on the Regional Fault Map, Figure 3. The San Andreas Fault is the dominant structure in the system, nearly spanning the length of California, and capable of producing the highest magnitude earthquakes. Many other subparallel or branch faults within the San Andreas system are equally active and nearly as capable of generating large earthquakes. Right-lateral movement dominates on these faults but an increasingly large amount of thrust faulting resulting from compression across the system is now being identified also.

The Sanchez Bypass and Neighborhood Sewer Rehabilitation Project is located on the flatlands surrounding San Francisco Bay about 2/3 of a mile west of the present tidal flats. The site is very near the pre-development margin of San Francisco Bay. Alluvium blankets the land between the Bay and the Peninsula segment of the Santa Cruz Mountains foothills where the project is located. These geologic units are shown on the Vicinity Geologic Map, Figure 4 (a portion of Pampeyan's 1994 published geologic map of the area).

2.2 REGIONAL SEISMICITY

The San Francisco Bay Area is recognized by geologists and seismologists as one of the most seismically active regions in the United States. The significant earthquakes that occur in the Bay Area are generally associated with crustal movement along well-defined, active fault zones of the San Andreas Fault system (see Figure 3), which regionally trend in a northwesterly direction. The San Andreas Fault, which generated the great San Francisco earthquake of 1906 and the Loma Prieta earthquake of 1989, passes about 1.6 miles southwest of the site. Three other major active faults in the area are the San Gregorio Fault, located about 7.9 miles southwest of the site, the Hayward Fault, located about 18 miles northeast and the Calaveras fault, located about 26 miles east. One potentially active fault in the site vicinity is the Monte Vista – Shannon Fault, located about 12.9 miles to the southwest. Table 1 lists all known active

faults in order of increasing distance within 25 kilometers (16.5 miles) of the project site. The seismic characteristics of some faults vary along its length so different segments of the same fault could be listed separately in the table.

Table 2: Known Active Faults Within 25-km Radius of Site

Fault Name	Distance	
	(miles)	(kilometers)
San Andreas	1.6	2.4
Monte Vista – Shannon	12.9	19.5
San Gregorio	13	20
Hayward (Total Length)	18	24
Hayward (South)	15	24

2.3 FUTURE EARTHQUAKE PROBABILITIES

Although research on earthquake prediction has greatly increased in recent years, seismologists cannot predict when or where an earthquake will occur. The U.S. Geological Survey's Working Group on California Earthquake Probabilities (2007) forecast a 99.7 percent chance of a magnitude 6.7 or greater earthquake somewhere in California before 2038. Previously, they (Working Group on California Earthquake Probabilities, 2003) determined there is a 62 percent chance of at least one magnitude 6.7 or greater earthquake striking the San Francisco Bay region between 2003 and 2032. This result is an important outcome of the investigation because any major earthquake can cause damage throughout the region. The probability of a magnitude 6.7 or greater earthquake on the peninsula segment of the San Andreas Fault, which is closest to the Sanchez Avenue Sanitary Sewer Rehabilitation Project site is believed to be 13 percent in that time period. During such an earthquake the danger of fault ground rupture at the site is slight, but strong ground shaking would occur.

This potential was demonstrated when the 1989 Loma Prieta earthquake caused severe damage in Oakland and San Francisco, more than 50 miles from the epicenter. Although earthquakes can cause damage at a considerable distance, shaking will be very intense near the fault rupture. Therefore, earthquakes centered in urbanized areas of the region have the potential to cause much more damage than the 1989 Loma Prieta earthquake.

SECTION 3: SITE CONDITIONS

3.1 SITE RECONNAISSANCE AND SURFACE DESCRIPTION

Our Principal Engineer performed a reconnaissance of the site on January 30, 2012. At the time of the reconnaissance the alignment of the Sanchez Avenue Sanitary Sewer Rehabilitation Project traversed developed land within the City of Burlingame. The area is largely developed as residential but with some light commercial along El Camino Real. The length of the alignment

slopes very gently toward the east. The existing asphalt concrete pavement within street right-of-way is cracked in some areas. There are no exposures of subsurface materials in the area due to the extensive development and landscaping. There are no substantial slopes in the immediate area.

3.2 LOCAL AREA GEOLOGY

A regional scale published map covering the general area of the site is shown on Figure 4, Vicinity Geologic Map. This figure is from regional mapping by Pampeyan (1994). Pampeyan's map of 1994 indicates the alignment of Sanchez Avenue Sanitary Sewer Rehabilitation Project traverses through an area underlain by Holocene Coarse-grained Alluvium (Qac). The Qac is described by Pampeyan as unconsolidated to consolidated, moderately sorted sand and silt that forms stream levees and alluvial fans along former and present drainage channels. The Qac is further described as locally containing lenticular interlayers of well-sorted silt, sand and gravel; and interfingers with the medium-grained mapping unit (Qam). Pampeyan shows a unit identified as sedimentary deposits (QTs) just to the southeast. Geologic mapping indicates that Franciscan Complex bedrock underlies the site at depths greater than 100 feet. Franciscan bedrock was encountered at a depth of 196 feet in a boring located southeast of the project site (Pampeyan, 1994).

3.3 SUBSURFACE GEOTECHNICAL CONDITIONS

The attached soil boring logs should be referenced for detailed descriptions of the subsurface soils at particular locations and depths.

3.3.1 Sanchez Avenue

Borings EB-1 through EB-4 were drilled in Sanchez Avenue, northeast of the El Camino Real, to depths of 15 to 25 feet, and EB-8 was drilled in Sanchez Avenue, west of the El Camino Real, to a depth of 21½ feet, all with truck mounted equipment at locations offset from the existing sewer locations. The eastern-most borings in Sanchez generally encountered 2 to 3 inches of asphalt concrete (AC) over older Portland cement concrete (PCC) pavements generally 2 to 3 inches thick. One (1) to 2 inches of aggregate base was encountered in several locations either over or under the PCC pavement. Borings EB-4 and EB-8 in Sanchez Avenue generally encountered 6 and 4 inches of AC over subgrade. In general, the pavement materials were underlain by mostly very stiff to hard clays or sandy clays, or medium dense to very dense sands or clayey sands. In Boring EB-1, the very dense conditions included abundant rock fragments and less recovery. Several samples had limited recovery; therefore, it is possible that large gravel fragments or cobbles are present at depth (deeper than about 10 to 13 feet).

We performed one Plasticity Index (PI) test on a soil sample obtained at a depth of 13½ feet in Boring EB-2 and classified as lean clay with sand (CL). The test result was used to aid in classifying the soils in this boring and other boring locations. The results of the PI test indicated a PI of 25, indicating a moderate plasticity.

3.3.2 Alleyways

Borings EB-5 through EB-7 were located in alleyways north and south of Sanchez Avenue between Chula Vista Avenue and Capuchino Avenue. The borings were drilled to depths of 14 to 15 feet with portable solid-flight auger drilling equipment in the utility right-of-ways and generally encountered about 1½ feet to 2½ feet of undocumented fill over mostly medium dense to hard clays and sandy clays with interbedded medium dense to dense clayey sand with gravel to the depth of our borings, similar to the borings in Sanchez.

3.3.3 Burlway Road and Bayshore Highway

Borings EB-9 and EB-10 were drilled with truck-mounted equipment at locations offset from the existing sewer in Burlway Road and Bayshore Highway. These borings generally encountered 9 inches of AC over subgrade in Burlway Road, and 2 inches of AC over a 14-inch cement-treated base over subgrade in Bayshore Highway. The pavements in both borings were generally underlain by sandy clay and clayey sand fill to a depth of approximately 8 to 9 feet below grade, over soft to very soft marine clays, known locally as Bay Mud, to the maximum depths explored of 25 feet. The moisture content of the Bay Mud ranged from approximately 54 to 80 percent.

3.4 GROUND WATER

Free groundwater was measured at the end of drilling in Borings EB-2, EB-6, EB-7 and EB-10 at depths of 22, 8, 10, and 7½ feet, respectively. Ground water was not encountered at the time of boring in the other borings. Ground water may occur at more shallow or deeper depths at other times because ground water levels fluctuations occur due to many factors including seasonal and regional fluctuations, leaks in water supply pipelines, perching, irrigation, underground drainage patterns and other factors.

SECTION 4: CONCLUSIONS AND DISCUSSION

4.1 POTENTIAL CONCERNS

Various sections of the existing sewer replacement or rehabilitation are planned to be constructed by one of the following methods: open cut construction, horizontal directionally drilled (HDD) installation method, pipe bursting method, or cast-in-place polymer pipe (CIPP) method. In addition, other trenchless methods are to be used at the El Camino Real crossing, and the replacement at Burlway Road and Bayshore Highway. Except as noted or discussed in following sections, our judgment is that the site area conditions are generally favorable for the planned construction methods provided the concerns listed below are addressed in the project design. Descriptions of each concern with brief outlines of our recommendations follow the listed concerns. Our general earthwork recommendations are provided in Section 5.0 following this section.

4.1.1 Residential Construction Areas

Most of the sewer rehabilitation project is located on, adjacent to, or close to residential areas where there will be concerns about construction noise and vibrations. For these reasons, our judgment is that installing either steel H-piles or sheet piles using impact equipment has substantial risk of being a nuisance, and that braced sheeting or drilled-in-place piles may be preferred.

4.1.2 Presence of Existing Utilities

Preliminary plans indicate the presence of existing utilities in the planned construction areas. An appropriate amount of clearance, discussed in more detail in following sections, is desirable to reduce the risk of damaging the existing utilities when installing the new sewer pipes.

4.1.3 Ground Displacement and Cracking

All of the planned sewer pipe construction methods, except for the CIPP sections, have the potential risk of causing ground displacements that may damage existing utilities or structures.

For open cut trenching, the shoring design and construction sequencing can address these potential risks.

For the HDD sections, these potential risks can be addressed by the depth of cover over the HDD alignment and paying close attention to and monitoring the HDD drilling pressures; however, even with these precautions, some risks of ground displacement, settling or cracking remain.

For the pipe bursting sections, these potential risks can be addressed by following general pipe bursting guidelines such as maintaining a clearance of 2 to 3 pipe diameters from adjacent or crossing utilities and structures or providing a clearance of at least 10 times the difference in diameters between the existing pipe and the new pipe. For example, where the existing pipe is 6 inch diameter and the new pipe is 8 inch diameter, the difference in diameters is 2 inches and the clearance from other utilities and structures should be at least 20 inches.

Additional information regarding general pipe bursting guidelines is available at:

- http://www.ttc.latech.edu/publications/guidelines_pb_im_pr/bursting.pdf

Additional information regarding trenchless construction is available at:

- http://www.dot.ca.gov/hq/traffops/developserv/permits/pdf/publications/HDD_Booklet.pdf

4.1.4 Shallow Ground Water

4.1.4.1 Sanchez Avenue and Alleyways

Ground water was not encountered until a depth of 22 feet in Boring EB-1, and was not encountered in the other Sanchez Avenue borings or the alleyway boring north of Sanchez; however, relatively shallow ground water was encountered in Borings EB-6 and EB-7 in the alleyways south of Sanchez at depths of 8 to 10 feet at the end of drilling. Static ground water elevations are not mapped by the State of California in this area, however, seasonally ground water could be encountered at depths greater than 15 feet below grade, and perched water could be expected to be carried in more granular layers above that, as observed in our alleyway borings.

4.1.4.2 Burlway Road and Bayshore Highway

Surface elevations in the area are about 9 feet (msl) based on our review of grades indicated on Google Earth™. This correlates relatively well with the 8 to 9 feet of fill encountered overlying Bay Mud. At the end of drilling, ground water was measured at a depth of 7½ feet in Boring EB-10 in Bayshore Highway; ground water was not encountered in Boring EB-9 in Burlway Road likely because the low-permeability clays prevented seepage fast enough to allow a stabilized ground water reading. However, excavations deeper than about 5 or 6 feet, left open overnight in the area, could expect to collect ground water. During periods of heavy rainfall, water can also perch on top of the Bay Mud in the area.

4.1.5 Presence of Bay Mud

As discussed, the area of Burlway Road and Bayshore Highway are underlain by 8 to 9 feet of fill and soft Bay Mud to a depth of at least 25 feet. Bay Mud presents many problems for construction projects, as it is typically saturated, soft, compressible, and prone to instability during excavation. Therefore, precautions should be taken when excavating, shoring, and working around Bay Mud. Additional recommendations are presented in the text of this report. Also, attached in Appendix C are our Guidelines for Construction on Bay Mud Sites.

4.1.6 Presence of Cobbles

The subsurface soils consist of layered, alluvial soils ranging from fine- to coarse-grained materials. In several of our borings along Sanchez Avenue, we encountered dense to very dense materials, and were only able to retrieve limited rock fragments in some of our sample locations, particularly Boring EB-1. In our opinion, this could indicate that course gravel, or occasional cobbles may be present at localized areas along the Sanchez Avenue alignment. The potential presence of dense to very dense materials should be considered when determining the final method and depth of trenchless installations.

4.2 MANHOLE FOUNDATION SUPPORT

4.2.1 Sanchez Avenue

Manhole foundations, bearing on undisturbed natural soils or fill compacted in accordance with our recommendations, at depths of 5 feet to 18 feet below the ground surface, are capable of supporting maximum allowable bearing pressures of 2,000 psf. As a working platform for construction, it may desirable to place 6 to 12 inches of crushed rock at the bottom of manhole excavations to stabilize and provide a better working surface than the moist, lean clays most prevalent along the segments.

4.2.2 Burlway Road and Bayshore Highway

Manhole foundations constructed over Bay Mud, or in Bay Mud, should be closely reviewed. An oversized base, and/or supplemental support by underlayment of several feet of crushed rock may be required to distribute loads and reduce bearing pressures. In addition, the weight of the manhole and the surrounding backfill materials should be considered. If the weight of the new manhole and associated backfill is heavier than previous soil removed, lightweight backfill materials may be required. Cornerstone should be retained to review planned manhole construction details in Bay Mud areas and provide supplemental recommendations.

4.3 OPEN CUT TRENCHING SECTIONS

4.3.1 Sanchez Avenue

Sewer replacement along Sanchez Avenue, along Paloma Avenue southeast of Sanchez Avenue, along Laguna Avenue northwest and southeast of Sanchez Avenue, and in an alleyway between Laguna Avenue and Chula Vista Avenue, are all planned for open cut construction. Planned pipe depths range from 16 feet to 10 feet along Sanchez Avenue, 5 to 18 feet along Paloma Avenue, 5 to 18 feet along Laguna Avenue, and 5 to 15 feet in the alleyway between Laguna Avenue and Chula Vista Avenue

We anticipate that a restrained excavation support system will be needed for most of these areas. Both the residential character of the construction areas and the very stiff to hard and dense soils preclude the use of driven H-piles or sheet piles or vibrated steel piles because of noise and vibration concerns and construction difficulties. Braced excavation support systems will most likely be required to limit detrimental lateral deflections and settlement behind temporary shoring. Temporary excavation support should be provided in accordance with our recommendations in Section 5.0 General Earthwork.

Ground water was either not measured or measured below the planned pipe depths along Sanchez Avenue; however, ground water was measured at depths of 8 and 10 feet at the end of drilling in Borings EB-6 and EB-7 in the alleyways southeast of Sanchez Avenue. Because of these variable ground water depths, potentially indicating perched water conditions in some granular layers, we recommend that contractors anticipate that localized dewatering may be necessary to control perched ground water, even in relatively shallow cuts. Perched ground

water conditions can be difficult to handle, and if the ground water is in a relatively widespread, continuous layer, it may be hard to dewater, requiring continuous dewatering during excavations.

4.3.2 Burlway Road and Bayshore Highway

There are several factors that may make an open cut trench repair method difficult for the sanitary sewer replacement at Burlway Road and Bayshore Highway. Below are several design considerations for an open cut trench repair at the site.

- The preliminary plans show a number of utilities in the upper 5 feet crossing the sewer rehabilitation pipe location. The number of utilities in the area would increase construction difficulty.

- The proposed invert would be approximately 7 to 8 feet below grade, or about 1 foot above the approximate transition to Bay Mud. Because of the soft underlying clays, potential “base heave” could occur if sufficient shoring embedment is not achieved. Continuous shoring would need to be used to provide stability, extending to at least 1½ times the trench width below the bottom of the excavation.

- A 33-inch sewer force main appears to be within about a ½ foot of the new replacement sewer. The preliminary sewer replacement alignment appears too close to existing utilities to satisfy usual suggested minimum clearances. A deeper alignment would put the new line closer to Bay Mud, or into Bay Mud.

- In the past, the underlying Bay Mud has settled under the weight of the previous backfill material, which is the likely cause of the sag in the line. This is a fairly common occurrence with utilities on Bay Mud sites. The backfill material used to backfill an open cut trench should no heavier than the materials removed, and using lightweight backfill for a portion of the trench is recommended.

- We understand that HDPE and/or PVC will be used as the new sanitary sewer line and that corrosivity of Bay Mud will not be a factor in design; Bay Mud is typically considered to be moderately to severely corrosive to buried concrete and metallic improvements.

- Ground water is relatively shallow in the area, and is generally considered to be at the top of Bay Mud for most bay margin sites. However, ground water also frequently perches over Bay Mud. Localized dewatering of the trench may need to be performed while excavations are open, depending on the final depth of the trench.

Trenchless construction alternatives include the bore and jack method or microtunneling. Both of these methods would require suitably sized manholes, or entry and exit pits, for the boring or microtunneling equipment. Microtunneling is judged to provide better control of ground loss and alignment than bore-and-jack.

4.4 TRENCHLESS METHODS

4.4.1 General

There are several soft ground trenchless tunneling techniques that could be used to install the pipes or casings in the planned undercrossings of El Camino Real and Bayshore Highway. It is our understanding that the bore-and-jack method is being considered at the referenced locations. Based on our understanding of the location of the undercrossing, the length, the subsurface and ground water conditions, and the approximate invert depths, we anticipate that this method is likely feasible. In our opinion, micro-tunneling may also be feasible for the project should there be a concern about ground loss, face support, or lateral and vertical guidance.

4.4.2 Bore-and-Jack Method

Bore-and-Jack is one of the trenchless technologies that can be used to install pipe/casings in the undercrossing. It is a multi-stage process consisting of constructing a temporary horizontal jacking platform and a starting alignment track in an entrance pit at a desired elevation. The casing is then jacked by manual control along the starting alignment track with simultaneous excavation of the soil being accomplished by a rotating cutting head in the leading edge of the product's annular space. The soil cuttings (spoils) are transported back to the entrance pit by helical auger flights rotating inside the casing. Bore-and-jack installation typically provides limited tracking and steering as well as limited support to the excavation face.

4.4.3 Microtunneling Method

Microtunneling is conducted similar to bore-and-jack procedures with the exception that it is a remotely controlled, guided pipe jacking process that provides continuous support to the excavation face. The guidance system usually consists of a laser mounted in the tunneling drive shaft which communicates a reference line to a target mounted inside the microtunneling machine's articulated steering head. The microtunneling process provides the ability to control the excavation face stability by applying mechanical or fluid pressure to counterbalance the earth and hydrostatic pressures.

4.5 POTENTIAL GROUND BEHAVIOR DURING INSTALLATION

4.5.1 El Camino Real Undercrossing

We do not know the invert elevation at this time for the planned undercrossing, although based on the depth of the 54-inch diameter S.F. Water Main, we expect that the invert will be at least 10 feet below grade, and likely not more than 20 feet below grade. This means that the ground conditions will primarily consist of dense clayey sand with gravel on the east side of El Camino Real, and lean clay at the west side of El Camino Real. Ground water is not expected at those depths, although encountering perched water is possible, as previously described.

4.5.2 Bayshore Highway Undercrossing

For the Bayshore Highway undercrossing, it appears that the ground conditions will consist primarily of soft, moist, blue gray sandy clay with gravel fill material, and soft, saturated, Bay Mud. The ground conditions should be closely reviewed prior to construction to determine the best method for completion of the undercrossing.

If the proximity of nearby utilities or the highway surface is deemed to be critical improvements, microtunneling could be used if greater control of stability at the face, reduced risk of ground loss, and improved guidance through the fill and Bay Mud is desired.

4.6 CONTROL OF GROUND WATER

4.6.1 El Camino Real Crossing

Ground water was measured at the end of drilling at 22 feet below grade in Boring EB-2; however, ground water was not encountered at the time of drilling at Borings EB-4 or EB-8, on either side of the El Camino Real, to a maximum depth of 21½ feet. However, perched water is possible, and localized dewatering to control seepage at entry and receiving pits may be required.

4.6.2 Burlway Road and Bayshore Highway

Ground water was encountered at a depth of about 7½ feet in Boring EB-10, and was not measured at the time of drilling in Boring EB-9. It is likely that ground water was not measured in Boring EB-9 because the low-permeability Bay Mud is slow to seep ground water. Either ground water or perched water was encountered in EB-10, and ground water could be encountered at similar depths during construction. Localized dewatering or several dewatering well points could be used to dewater the entry and receiving pits.

4.7 CASING PIPE CONSIDERATIONS

Important trenchless installation considerations are related to design of the pipe casing and construction control during jacking. The pipe should be designed to accommodate the axial jacking stresses, as well as the earth loads due to the full overburden pressure. Fabrication of the pipe is also important, as unacceptable eccentric stresses may develop in the pipe during jacking if the ends are not within the tolerance for alignment.

4.8 CLEARANCE OF UTILITIES

We understand that there are existing utility lines present at the proposed undercrossing. An appropriate amount of clearance is desirable to reduce the risk of damaging the existing utilities when installing the new casings. If possible, maintaining a minimum clearance of two casing diameters from existing utilities is preferred. Where utilities are critical, or are within about 2 casing diameters or 5 feet, we also recommend potholing to confirm the location, where feasible to do so.

4.9 PIPE-JACKING SUBMITTALS

The Contractor should be required to submit the following:

- Details of the Bore-and-Jack equipment, including thrust calculations.
- Method of monitoring line-and-grade
- Steering system details
- Thrust block design
- Casing type thickness and calculations indicating adequacy under jacking forces
- Details of shield or other provisions to support tunnel face
- Method for placing carrier pipeline inside casing (if occurring)
- Shoring design
- Backfilling annular space and grouting provisions

Where workers will enter tunnels or underground chambers at any depth, or where pit excavations will be greater than 20 feet in depth, a preliminary gas classification will likely be required in accordance with Title 8, Division of Industrial Safety, Tunnel Safety Orders. The gas classification determined by CAL/OSHA should be incorporated into the project specifications.

4.10 JACKING AND RECEIVING PITS

Vertical excavations on the order of 10 to 20 feet are anticipated to construct entry and exit pits. These excavations will be made adjacent to existing utilities and within city streets and, therefore, will require temporary support in order to avoid damaging the adjacent streets, sidewalks, utilities, and other improvements. Excavation of the pits should be readily accomplished with standard backhoes and excavators during or after shoring installations.

The Contractor should be responsible for all temporary slopes and design of any required shoring. The design of the shoring at entry and exit pits, as well as design of the jacking system, should be performed by a Registered Civil or Structural Engineer, retained by the Contractor, and submitted to the Engineer prior to its implementation. Shoring, bracing or temporary slopes should be performed by the Contractor in accordance with the strictest governing safety standards.

Vertical excavations may be temporarily shored using sheet piling, soldier piles and lagging, braced shoring or other shoring schemes, depending on the judgment of the shoring designer and Contractor. We recommend that the lateral soil pressures presented on Figure 5 and 6, be used in the design of temporary shoring. As indicated on Figures 5 and 6, the excavation shoring should be designed for additional surcharge loads due to normal street loads or other surcharge loads. To prevent excessive surcharging of the walls from heavy construction vehicles, such as concrete trucks, we recommend that such vehicles be kept at least 15 feet from the top of the excavations. If this is not possible, the shoring must be designed to resist the additional lateral loads. In addition, all shoring schemes should be designed with sufficient rigidity to prevent detrimental displacements at the top of the shoring, particularly where

excavations are completed adjacent to existing utilities, pavements or other improvements. At a minimum, the wall should be designed for a minimum surcharge of 240 psf for the upper 6 feet behind the wall to account for inadvertent surcharging. For a restrained wall, this would result in a minimum uniform lateral earth pressure of 120 psf in the upper 6 feet of wall. Where shaft or pit excavations are supported with temporary shoring, some settlement of the adjacent ground surface should be anticipated. If these shored excavations are placed in paved streets, some cracking and settlement of the adjacent pavements should be anticipated. Good design and construction techniques should greatly reduce these types of distress to improvements. The project specifications should require restoration of these damaged pavements, curbs, gutters, etc., to their preconstruction condition. A precondition survey of the area performed by the Contractor prior to construction, including photos, should be considered.

We performed our borings with hollow-stem auger drilling equipment and as such were not able to evaluate the potential for caving soils, which can create difficult conditions during soldier beam or soil nail installation; caving soils can also be problematic during excavation and lagging placement. The contractor is responsible for evaluating excavation difficulties prior to construction. Where relatively clean sands or cobble conditions were encountered during our exploration, pilot holes performed by the contractor may be desired to further evaluate these conditions prior to the finalization of the shoring budget. Shoring contractors should take into consideration the potential for slower production rates, and increased tie-back shaft diameter (i.e. higher grout take) due to cobbles.

In addition to anticipated deflection of the shoring system, other factors such as voids created by soil sloughing, and erosion of granular layers due to perched water conditions can create adverse ground subsidence and deflections. The contractor should attempt to cut the excavation as close to neat lines as possible; where voids are created they should be backfilled as soon as possible with sand, gravel, or grout.

The above recommendations are for the use of the design team; the contractor, in conjunction with input from the shoring designer, should perform additional subsurface exploration they deem necessary to design the chosen shoring system. A California-licensed civil or structural engineer must design and be in responsible charge of the temporary shoring design. The contractor is responsible for means and methods of construction, as well as site safety.

4.11 HORIZONTAL DIRECTIONAL DRILLING ALLEYWAY SECTIONS

Two of the sewer replacement sections, which are planned to be constructed using HDD construction, will include an 8-inch diameter, 265-foot-long sewer section in an alleyway southeast of Sanchez Avenue between Capuchino Avenue and Paloma Avenue, and an 8-inch diameter, 168-foot-long sewer section in an alleyway southeast of Sanchez Avenue between Paloma Avenue and Laguna Avenue. Pipe depths will vary from 5 to 18 feet along these sections, with inverts being deepest at Sanchez Avenue and shallowest away from Sanchez Avenue. We anticipate that the drilling entry points for these sections will be located away from Sanchez Avenue on residential properties, or alternatively from manholes along Sanchez Avenue sized for the HDD equipment. As previously discussed, the HDD method has potential risks of ground displacement, cracking, and release of drilling fluids, especially where the depth

of cover is least. The potential for ground surface cracking can be reduced by limiting drilling fluid pressures to near or less than total overburden stresses, or near or less than about 0.7 to 0.8 pounds per square inch per foot of depth or cover.

4.12 PIPE BURSTING SECTIONS

While subsurface conditions represented by the borings are generally suitable for the planned pipe bursting sections there are associated risks of ground displacement and damage to existing utilities and structures, as previously discussed. Other excavation and earthwork associated with the pipe bursting section should follow our general earthwork recommendations included in following Section 5.0.

4.13 CAST-IN-PLACE POLYMER PIPE SECTIONS

Excavations and earthwork associated with the cast-in-Place polymer pipe sections should follow our general earthwork recommendations included in following Section 5.0.

4.14 PRESENCE OF GRAVEL DEPOSITS

Borings EB-6 and EB-7 encountered some soil layers with fine to coarse gravel that may potentially affect the two planned HDD construction method sewer replacement.

4.15 PLANS AND SPECIFICATIONS REVIEW

We recommend that we be retained to review the geotechnical aspects of the project structural, civil, and landscape plans and specifications, allowing sufficient time to provide the design team with any comments prior to issuing the plans for construction.

4.16 CONSTRUCTION OBSERVATION

As site conditions may vary significantly between the small-diameter borings performed during this investigation, we also recommend that a Cornerstone representative be present to provide geotechnical observation and testing during earthwork and related construction activities. This will allow us to form an opinion and prepare a letter at the end of construction regarding contractor compliance with project plans and specifications, and with the recommendations in our report. We will also be allowed to evaluate any conditions differing from those encountered during our investigation, and provide supplemental recommendations as necessary. For these reasons, the recommendations in this report are contingent of Cornerstone providing observation and testing during construction. Contractors should provide at least a 48-hour notice when scheduling our field personnel.

SECTION 5.0 GENERAL EARTHWORK

The earthwork anticipated for this project is likely to consist of clearing the entry/exit pit areas pits of surface pavements, excavating the entry/exit pits, installation and removal of temporary

shoring systems, backfilling of the entry/exit pits and restoration of the surface pavement improvements. These are discussed in the following sections.

5.1 CLEARING AND SPOIL DISPOSAL

In the designated areas of the entry/exit pits, the site should be cleared of all surface and subsurface deleterious materials including existing pavements, curb and gutter, buried utility and irrigation lines, debris, designated trees, shrubs, and associated roots. All deleterious materials should be removed from the site and properly disposed of in accordance with regulatory requirements.

5.2 MATERIAL FOR FILL

All on-site soils below the stripped layer, except for underlying Bay Mud in the Bayshore Highway area, having an organic content of less than 3 percent by weight are suitable for re-use as fill at the site. In general, fill material should not contain rocks or lumps larger than 6 inches in greatest dimension, with no more than 1.5 percent larger than 2½ inches. Imported fill material should be predominantly granular with a Plasticity Index of 15 or less. To prevent significant caving during future trenching or excavations, imported material should have sufficient fines. Samples of potential import sources should be delivered to our office at least 10 days prior to the desired import start date. Information regarding the import source should be provided, such as any site geotechnical and environmental reports.

Environmental and soil corrosion characterization should also be considered by the project team prior to acceptance. Suitable environmental laboratory data to the planned import quantity should be provided to the project environmental consultant; additional laboratory testing may be required based on the project environmental consultant's review. The potential import source should also not be more corrosive than the on-site soils, based on pH, saturated resistivity, and soluble sulfate and chloride testing.

5.3 COMPACTION OF PIT BACKFILL

All backfill should be compacted in accordance with the City of Burlingame requirements or the recommendations contained in this section, whichever is more stringent. Fill material should be placed in lifts not exceeding 8 inches in uncompacted thickness and should be compacted to at least 90 percent relative compaction (ASTM D1557, latest edition) by mechanical means only. The aggregate base and pavement sections should be restored to their original thicknesses and grades or as required by the City of Burlingame. The upper 6 inches of subgrade in pavement areas and all aggregate base should be compacted to at least 95 percent relative compaction (ASTM D1557, latest edition). Aggregate base and all import soils should be compacted at a moisture content near the laboratory optimum.

5.4 PLANS AND SPECIFICATIONS REVIEW

We recommend that we be retained to review the geotechnical aspects of the project structural, civil, and landscape plans and specifications, allowing sufficient time to provide the design team with any comments prior to issuing the plans for construction.

5.5 CONSTRUCTION OBSERVATION

As site conditions may vary significantly between the small-diameter borings performed during this investigation, we also recommend that a Cornerstone representative be present to provide geotechnical observation and testing during earthwork and related construction activities. This will allow us to form an opinion and prepare a letter at the end of construction regarding contractor compliance with project plans and specifications, and with the recommendations in our report. We will also be allowed to evaluate any conditions differing from those encountered during our investigation, and provide supplemental recommendations as necessary. For these reasons, the recommendations in this report are contingent of Cornerstone providing observation and testing during construction. Contractors should provide at least a 48-hour notice when scheduling our field personnel.

5.6 THRUST BLOCK DESIGN

Where a thrust block is required to transfer jacking loads into the soil, it shall be properly designed and constructed by the Contractor. Lateral resistance may be provided by passive pressures acting against the side of thrust blocks poured neat against competent soil.

5.6.1 El Camino Real Crossing

Assuming an average embedment of 10 feet or greater, we recommend that an ultimate passive pressure based on a uniform pressure of 3,500 pounds per square foot (psf) be used in design of thrust blocks. The thrust block shall be normal (square) with the proposed pipe alignment and shall be designed to withstand the maximum jacking pressure to be used with a factor of safety of at least 2.0. It shall also be designed to minimize excessive deflections in such a manner as to avoid disturbance of adjacent structures or utilities or excessive ground movement. If a concrete thrust block is utilized to transfer jacking loads into the soil, the tunnel boring is not to be jacked until the concrete or other materials have attained the required strength.

5.6.2 Burlway Road and Bayshore Highway

Assuming an average embedment of 9 feet, we recommend that an ultimate passive pressure based on a uniform pressure of 750 pounds per square foot (psf) be used in design of thrust blocks. If the average embedment is deeper than 10 feet, then the ultimate passive pressures should be reduced to 400 psf in the Bay Mud. The thrust block shall be normal (square) with the proposed pipe alignment and shall be designed to withstand the maximum jacking pressure to be used with a factor of safety of at least 2.0. It shall also be designed to minimize excessive deflections in such a manner as to avoid disturbance of adjacent structures or utilities or

excessive ground movement. If a concrete thrust block is utilized to transfer jacking loads into the soil, the tunnel boring is not to be jacked until the concrete or other materials have attained the required strength.

SECTION 7: LIMITATIONS

This report, an instrument of professional service, has been prepared for the sole use of Hatch Mott McDonald specifically to support the design of the Sanchez Bypass and Neighborhood Sewer Rehabilitation Project project in Burlingame, California. The opinions, conclusions, and recommendations presented in this report have been formulated in accordance with accepted geotechnical engineering practices that exist in Northern California at the time this report was prepared. No warranty, expressed or implied, is made or should be inferred.

Recommendations in this report are based upon the soil and ground water conditions encountered during our subsurface exploration. If variations or unsuitable conditions are encountered during construction, Cornerstone must be contacted to provide supplemental recommendations, as needed.

Hatch Mott McDonald may have provided Cornerstone with plans, reports and other documents prepared by others. Hatch Mott McDonald understands that Cornerstone reviewed and relied on the information presented in these documents and cannot be responsible for their accuracy.

Cornerstone prepared this report with the understanding that it is the responsibility of the owner or his representatives to see that the recommendations contained in this report are presented to other members of the design team and incorporated into the project plans and specifications, and that appropriate actions are taken to implement the geotechnical recommendations during construction.

Conclusions and recommendations presented in this report are valid as of the present time for the development as currently planned. Changes in the condition of the property or adjacent properties may occur with the passage of time, whether by natural processes or the acts of other persons. In addition, changes in applicable or appropriate standards may occur through legislation or the broadening of knowledge. Therefore, the conclusions and recommendations presented in this report may be invalidated, wholly or in part, by changes beyond Cornerstone's control. This report should be reviewed by Cornerstone after a period of three (3) years has elapsed from the date of this report. In addition, if the current project design is changed, then Cornerstone must review the proposed changes and provide supplemental recommendations, as needed.

An electronic transmission of this report may also have been issued. While Cornerstone has taken precautions to produce a complete and secure electronic transmission, please check the electronic transmission against the hard copy version for conformity.

Recommendations provided in this report are based on the assumption that Cornerstone will be retained to provide observation and testing services during construction to confirm that conditions are similar to that assumed for design, and to form an opinion as to whether the work

has been performed in accordance with the project plans and specifications. If we are not retained for these services, Cornerstone cannot assume any responsibility for any potential claims that may arise during or after construction as a result of misuse or misinterpretation of Cornerstone's report by others. Furthermore, Cornerstone will cease to be the Geotechnical-Engineer-of-Record if we are not retained for these services.

SECTION 8: REFERENCES

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CORNERSTONE EARTH GROUP

Vicinity Map

Sanchez Avenue Sewer Rehabilitation
Burlingame, CA

Project Number	522-1-1
Figure Number	Figure 1
Date	February 2012
Drawn By	RRN

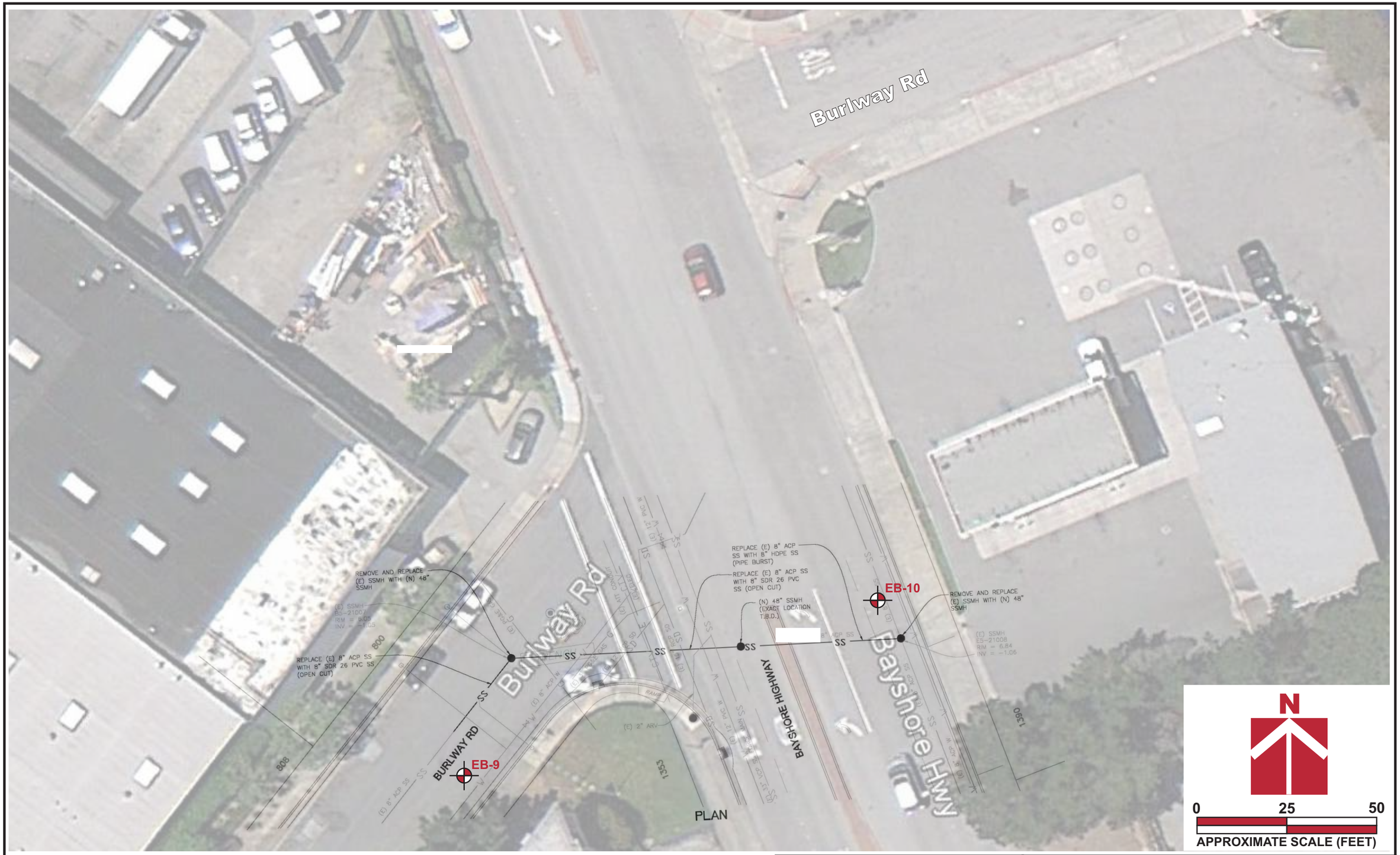
Legend

Approximate location of Exploratory Boring (EB)

Base by Google Earth, dated 6/19/2011
Overlay by Hatch Mott MacDonald, "Location - Plan," dated 2/10/2012

CORNERSTONE EARTH GROUP

Sanchez Avenue Sewer Rehabilitation	Figure Number: Figure 2A
Sanchez Avenue Sewer Rehabilitation Burlingame, CA	Project Number: 522-1-1
	Date: February 2012



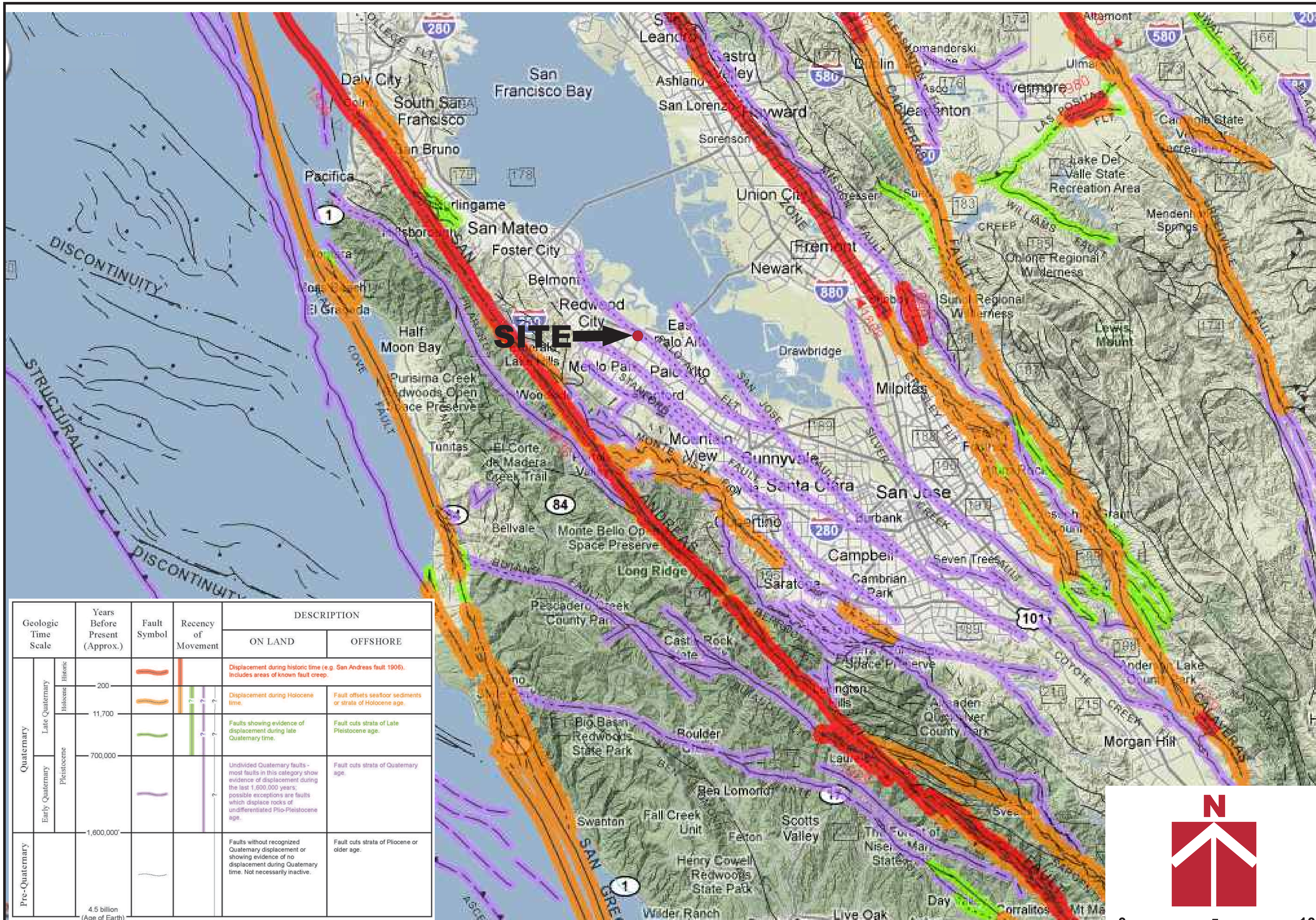
Legend

Approximate location of exploratory boring (EB)

Base by Google Earth, dated 6/19/2011
Overlay by Hatch Mott MacDonald, "Burlway Road and Bayshore Road Intersection Plan," dated 2/10/2012

CORNERSTONE EARTH GROUP

Burlway Road and Bayshore Highway Sewer Rehabilitation	Figure Number: Figure 2B
Sanchez Avenue Sewer Rehabilitation Burlingame, CA	Project Number: 522-1-1
	Date: February 2012



Geologic Time Scale			Years Before Present (Approx.)	Fault Symbol	Recency of Movement	DESCRIPTION: ON LAND	DESCRIPTION: OFFSHORE
Quaternary	Late Quaternary	Historic				Displacement during historic time (e.g. San Andreas fault 1906). Includes areas of known fault creep.	
		Holocene	200		? ? ?	Displacement during Holocene time.	Fault offsets seafloor sediments or strata of Holocene age.
		Pleistocene	11,700		? ?	Faults showing evidence of displacement during late Quaternary time.	Fault cuts strata of Late Pleistocene age.
	Early Quaternary		700,000		?	Undivided Quaternary faults - most faults in this category show evidence of displacement during the last 1,600,000 years; possible exceptions are faults which displace rocks of undifferentiated Plio-Pleistocene age.	Fault cuts strata of Quaternary age.
Pre-Quaternary			1,600,000 — 4.5 billion (Age of Earth)			Faults without recognized Quaternary displacement or showing evidence of no displacement during Quaternary time. Not necessarily inactive.	Fault cuts strata of Pliocene or older age.

Base by California Geological Survey - 2010 Fault Activity Map of California (Jennings and Bryant, 2010)

Regional Fault Map

Sanchez Avenue Sewer Rehabilitation
Burlingame, CA

Project Number 522-1-1
Figure Number Figure 3
Date February 2012
Drawn By RRN

CORNERSTONE EARTH GROUP

Geologic Units

Qf Artificial fill (Holocene)

Qac Coarse-grained alluvium (Holocene)

Explanation

Contact- dashed where approximate, dotted where concealed

N

0 2000 4000

APPROXIMATE SCALE (FEET)

Base by Pampeyan

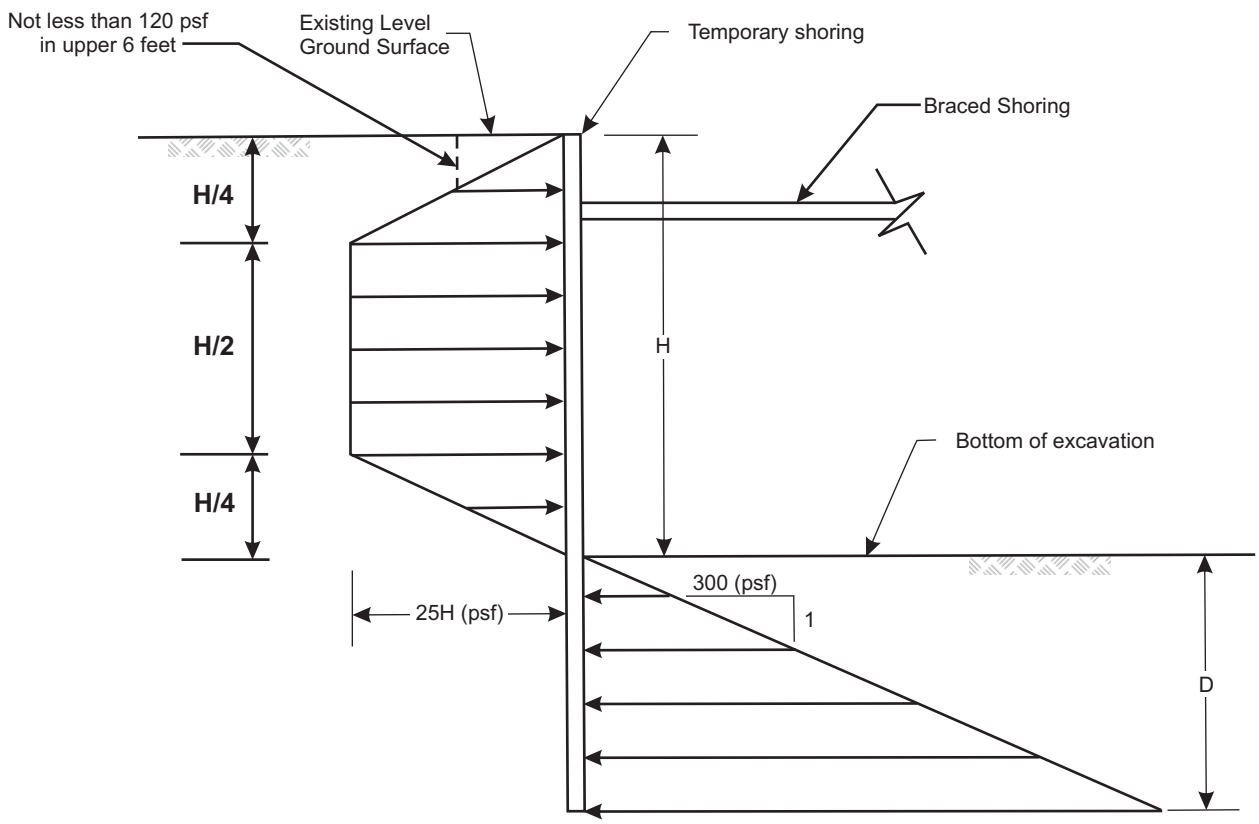
CORNERSTONE EARTH GROUP

Vicinity Geologic Map

Sanchez Avenue Sewer Rehabilitation
Burlingame, CA

Project Number	522-1-1
Figure Number	Figure 4
Date	February 2012
Drawn By	RRN

Lateral Earth Pressures - Braced Shoring



H = Height of temporary shoring above the bottom of the excavation (feet)

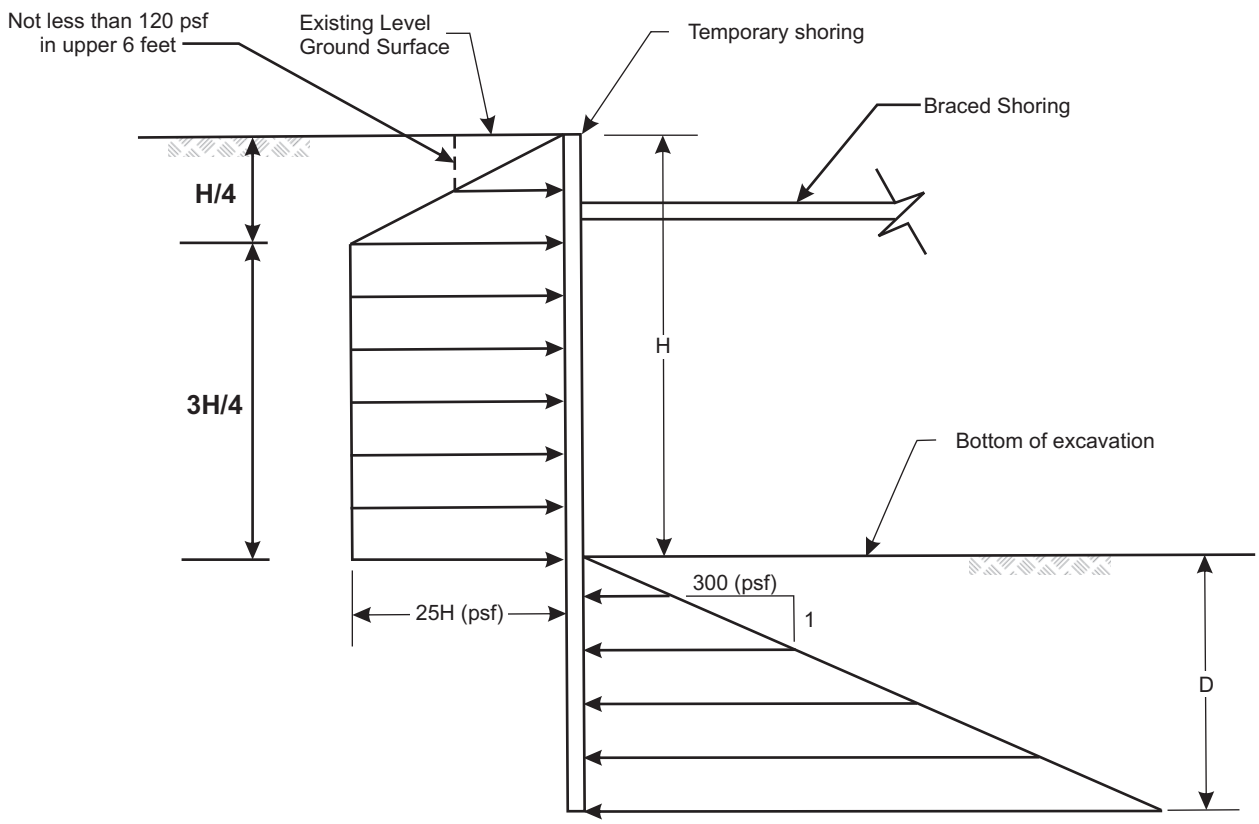
D = Depth of embedment of vertical members (feet)

Notes:

1. The above pressures are for walls with a level surface behind them; these pressures must be increased if the ground behind the temporary shoring slopes upward.
2. Passive pressure can be used over twice the projected area of the soldier pile.
3. The above pressures do not include surcharge loads. Walls should be designed to resist an additional uniform pressure equivalent ot one-half of any uniform surcharge loads.
4. Minimum earth pressure of 120 psf should be used in upper 6 feet to account for inadvertent surcharges.

CORNERSTONE EARTH GROUP	Lateral Earth Pressures - Sanchez Avenue	Project Number 522-1-1
	Sanchez Avenue Sewer Rehabilitation Burlingame, CA	Figure Number Figure 5
		Date February 2012 / Drawn By MGV, RRN

Lateral Earth Pressures - Braced Shoring



H = Height of temporary shoring above the bottom of the excavation (feet)

D = Depth of embedment of vertical members (feet)

Notes:

1. The above pressures are for walls with a level surface behind them; these pressures must be increased if the ground behind the temporary shoring slopes upward.
2. Passive pressure can be used over twice the projected area of the soldier pile.
3. The above pressures do not include surcharge loads. Walls should be designed to resist an additional uniform pressure equivalent ot one-half of any uniform surcharge loads.
4. Minimum earth pressure of 120 psf should be used in upper 6 feet to account for inadvertent surcharges.

CORNERSTONE EARTH GROUP	Lateral Earth Pressures - Bayshore Highway	Project Number 522-1-1
	Sanchez Avenue Sewer Rehabilitation Burlingame, CA	Figure Number Figure 6
		Date February 2012 / Drawn By MGV, RRN

APPENDIX A: FIELD INVESTIGATION

The field investigation consisted of a surface reconnaissance and a subsurface exploration program using truck-mounted hollow-stem auger drilling equipment for seven of the borings (Borings EB-1, EB-2, EB-3, EB-4, EB-8, EB-9 and EB-10) and portable solid-auger equipment for Borings EB-5, EB-6 and EB-7). The portable solid auger borings were drilled in areas not accessible by the truck-mounted equipment. Four of the hollow-stem borings were drilled on January 23, 2012 and three were drilled on February 10, 2012. The three solid-auger borings were drilled on January 26, 2012. Maximum boring depths ranged from 14 to 25 feet. The approximate locations of exploratory borings are shown on the Site Plan, Figure 2. The soils encountered were continuously logged in the field by our representative and described in accordance with the Unified Soil Classification System (ASTM D2488). Boring logs and Test Pit Logs, as well as a key to the classification of the soil and bedrock, are included as part of this appendix.

Boring and test pit locations were approximated using existing site boundaries and other site features as references. Boring elevations were not determined by Cornerstone. The locations of the borings should be considered accurate only to the degree implied by the method used.

Representative soil samples were obtained from the borings at selected depths. All samples were returned to our laboratory for evaluation and appropriate testing. The standard penetration resistance blow counts were obtained by dropping a 140-pound hammer through a 30-inch free fall. The 2-inch O.D. split-spoon sampler was driven 18 inches and the number of blows was recorded for each 6 inches of penetration (ASTM D1586). 2.5-inch I.D. samples were obtained using a Modified California Sampler driven into the soil with the 140-pound hammer previously described. Relatively undisturbed samples were also obtained with 2.875-inch I.D. Shelby Tube sampler which were hydraulically pushed. Unless otherwise indicated, the blows per foot recorded on the boring log represent the accumulated number of blows required to drive the last 12 inches. The various samplers are denoted at the appropriate depth on the boring logs.

Field tests included an evaluation of the unconfined compressive strength of the soil samples using a pocket penetrometer device. The results of these tests are presented on the individual boring logs at the appropriate sample depths.

Attached boring logs and related information depict subsurface conditions at the locations indicated and on the date designated on the logs. Subsurface conditions at other locations may differ from conditions occurring at these boring and test pit locations. The passage of time may result in altered subsurface conditions due to environmental changes. In addition, any stratification lines on the logs represent the approximate boundary between soil types and the transition may be gradual.

UNIFIED SOIL CLASSIFICATION (ASTM D-2487-10)

MATERIAL TYPES	CRITERIA FOR ASSIGNING SOIL GROUP NAMES			GROUP SYMBOL	SOIL GROUP NAMES & LEGEND
COARSE-GRAINED SOILS >50% RETAINED ON NO. 200 SIEVE	GRAVELS >50% OF COARSE FRACTION RETAINED ON NO 4. SIEVE	CLEAN GRAVELS <5% FINES	Cu>4 AND 1<Cc<3	GW	WELL-GRADED GRAVEL
			Cu>4 AND 1>Cc>3	GP	POORLY-GRADED GRAVEL
		GRAVELS WITH FINES >12% FINES	FINES CLASSIFY AS ML OR CL	GM	SILTY GRAVEL
			FINES CLASSIFY AS CL OR CH	GC	CLAYEY GRAVEL
	SANDS >50% OF COARSE FRACTION PASSES ON NO 4. SIEVE	CLEAN SANDS <5% FINES	Cu>6 AND 1<Cc<3	SW	WELL-GRADED SAND
			Cu>6 AND 1>Cc>3	SP	POORLY-GRADED SAND
		SANDS AND FINES >12% FINES	FINES CLASSIFY AS ML OR CL	SM	SILTY SAND
			FINES CLASSIFY AS CL OR CH	SC	CLAYEY SAND
FINE-GRAINED SOILS >50% PASSES NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT<50	INORGANIC	PI>7 AND PLOTS>"A" LINE	CL	LEAN CLAY
			PI>4 AND PLOTS<"A" LINE	ML	SILT
		ORGANIC	LL (oven dried)/LL (not dried)<0.75	OL	ORGANIC CLAY OR SILT
	SILTS AND CLAYS LIQUID LIMIT>50	INORGANIC	PI PLOTS >"A" LINE	CH	FAT CLAY
			PI PLOTS <"A" LINE	MH	ELASTIC SILT
		ORGANIC	LL (oven dried)/LL (not dried)<0.75	OH	ORGANIC CLAY OR SILT
HIGHLY ORGANIC SOILS		PRIMARILY ORGANIC MATTER, DARK IN COLOR, AND ORGANIC ODOR		PT	PEAT

OTHER MATERIAL SYMBOLS

- Poorly-Graded Sand with Clay
- Clayey Sand
- Sandy Silt
- Artificial/Undocumented Fill
- Poorly-Graded Gravelly Sand
- Topsoil
- Well-Graded Gravel with Clay
- Well-Graded Gravel with Silt
- Sand
- Silt
- Well Graded Gravelly Sand
- Gravelly Silt
- Asphalt
- Boulders and Cobble

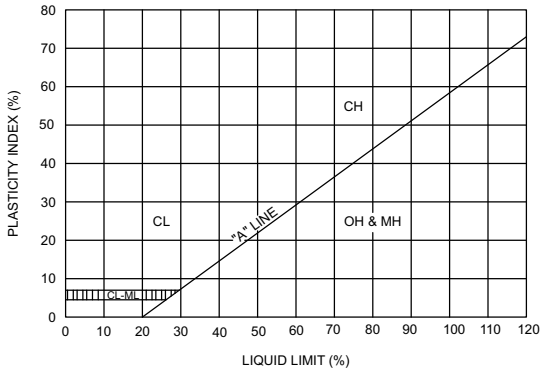
SAMPLER TYPES

- SPT
- Modified California (2.5" I.D.)
- Rock Core
- Shelby Tube
- No Recovery
- Grab Sample

ADDITIONAL TESTS

CA	-	CHEMICAL ANALYSIS (CORROSIVITY)	PI	-	PLASTICITY INDEX
CD	-	CONSOLIDATED DRAINED TRIAXIAL	SW		SWELL TEST
CN	-	CONSOLIDATION	TC	-	CYCLIC TRIAXIAL
CU	-	CONSOLIDATED UNDRAINED TRIAXIAL	TV	-	TORVANE SHEAR
DS	-	DIRECT SHEAR	UC	-	UNCONFINED COMPRESSION
PP	-	POCKET PENETROMETER (TSF)	(1.5)	-	(WITH SHEAR STRENGTH IN KSF)
(3.0)	-	(WITH SHEAR STRENGTH IN KSF)		-	
RV	-	R-VALUE	UU		UNCONSOLIDATED UNDRAINED TRIAXIAL
SA	-	SIEVE ANALYSIS: % PASSING #200 SIEVE		-	
	-	WATER LEVEL			

PLASTICITY CHART



PENETRATION RESISTANCE
(RECORDED AS BLOWS / FOOT)

SAND & GRAVEL		SILT & CLAY		
RELATIVE DENSITY	BLOWS/FOOT*	CONSISTENCY	BLOWS/FOOT*	STRENGTH** (KSF)
VERY LOOSE	0 - 4	VERY SOFT	0 - 2	0 - 0.25
LOOSE	4 - 10	SOFT	2 - 4	0.25 - 0.5
MEDIUM DENSE	10 - 30	MEDIUM STIFF	4 - 8	0.5-1.0
DENSE	30 - 50	STIFF	8 - 15	1.0 - 2.0
VERY DENSE	OVER 50	VERY STIFF	15 - 30	2.0 - 4.0
		HARD	OVER 30	OVER 4.0

* NUMBER OF BLOWS OF 140 LB HAMMER FALLING 30 INCHES TO DRIVE A 2 INCH O.D. (1-3/8 INCH I.D.) SPLIT-BARREL SAMPLER THE LAST 12 INCHES OF AN 18-INCH DRIVE (ASTM-1586 STANDARD PENETRATION TEST).

** UNDRAINED SHEAR STRENGTH IN KIPS/SQ. FT. AS DETERMINED BY LABORATORY TESTING OR APPROXIMATED BY THE STANDARD PENETRATION TEST, POCKET PENETROMETER, TORVANE, OR VISUAL OBSERVATION.

CORNERSTONE EARTH GROUP

LEGEND TO SOIL DESCRIPTIONS

Figure Number A-1

BORING NUMBER EB-1

CORNERSTONE EARTH GROUP

PROJECT NAME Sanchez Avenue Sewer Rehab
PROJECT NUMBER 522-1-1
PROJECT LOCATION Burlingame, CA

DATE STARTED 1/23/12 **DATE COMPLETED** 1/23/12
GROUND ELEVATION **BORING DEPTH** 18.6 ft.
DRILLING CONTRACTOR Exploration Geoservices, Inc.
LATITUDE **LONGITUDE**
DRILLING METHOD Mobile B-40, 8 inch Hollow-Stem Auger
GROUND WATER LEVELS:
LOGGED BY NBZ
AT TIME OF DRILLING Not Encountered
NOTES
AT END OF DRILLING Not Encountered

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ELEVATION (ft)	DEPTH (ft)	SYMBOL	DESCRIPTION	N-Value (uncorrected) blows per foot	SAMPLES TYPE AND NUMBER	DRY UNIT WEIGHT PCF	NATURAL MOISTURE CONTENT, %	PLASTICITY INDEX, %	PERCENT PASSING NO. 200 SIEVE	UNDRAINED SHEAR STRENGTH, ksf (○ HAND PENETROMETER, △ TORVANE, ● UNCONFINED COMPRESSION, ▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL; 1.0 2.0 3.0 4.0 5.0)
	0		2½ inches asphalt concrete over 3 inches Portland cement concrete and 1 inch aggregate base							
			Sandy Lean Clay (CL) hard, moist, brown, fine to medium sand, low to moderate plasticity							
	5			67	MC-1B	113	16			○
			Clayey Sand with Gravel (SW) very dense, moist, dark gray with brown mottles, fine to medium sand, with abundant rock fragments	50 / 5"	MC-2B	126	5			
	10			50 / 5"	SPT-3		4			
			gray, possible cobbles or boulders	50 / 6"	SPT-4		4			
	15									
			moderately hard, weak, little weathering	50 / 1"	SPT-5					
			Bottom of Boring at 18.6 feet.							
	20									
	25									

CORNERSTONE EARTH GROUP - CORNERSTONE.GDT - 2/28/12 13:43 - P:\DRAFTING\GINT FILES\522-1-1 SANCHEZ SEWER REHAB.GPJ

BORING NUMBER EB-10

CORNERSTONE EARTH GROUP

PROJECT NAME Sanchez Avenue Sewer Rehab
PROJECT NUMBER 522-1-1
PROJECT LOCATION Burlingame, CA

DATE STARTED 2/10/12 **DATE COMPLETED** 2/10/12
GROUND ELEVATION **BORING DEPTH** 25 ft.
DRILLING CONTRACTOR Access Soil Drilling, Inc.
LATITUDE **LONGITUDE**
DRILLING METHOD Minuteman, 4 inch Solid Flight Auger
GROUND WATER LEVELS:
LOGGED BY NBZ
AT TIME OF DRILLING 7.5 ft.
NOTES
AT END OF DRILLING 7.5 ft.

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ELEVATION (ft)	DEPTH (ft)	SYMBOL	DESCRIPTION	N-Value (uncorrected) blows per foot	SAMPLES TYPE AND NUMBER	DRY UNIT WEIGHT PCF	NATURAL MOISTURE CONTENT, %	PLASTICITY INDEX, %	PERCENT PASSING NO. 200 SIEVE	UNDRAINED SHEAR STRENGTH, ksf (○ HAND PENETROMETER, △ TORVANE, ● UNCONFINED COMPRESSION, ▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL; 1.0 2.0 3.0 4.0 5.0)
	0		2" asphalt concrete over 14" cement treated agrregate base							
			Lean Clay with Sand (CL) [Fill] moist, brown, fine to coarse sand, low to moderate plasticity							
	5		**Clayey Sand with Gravel (SC) [Fill]** loose, moist, brown, fine to coarse sand, fine to coarse angular gravel		MC-1					
			Sandy Fat Clay with Gravel (CH) [Fill] soft, moist, blue gray, fine to coarse sand, fine subrounded gravel	15	MC-2	125	24			
	10		**Fat Clay (CH) [Bay Mud]** soft, moist to wet, blue gray to dark gray, high plasticity		ST					
				4	MC-4	55	70			
	15									
				7	MC-5B	66	54			
	20									
				7	MC-6B	52	78			
	25		Bottom of Boring at 25.0 feet.							

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BORING NUMBER EB-2

CORNERSTONE EARTH GROUP

PROJECT NAME Sanchez Avenue Sewer Rehab
PROJECT NUMBER 522-1-1
PROJECT LOCATION Burlingame, CA

DATE STARTED 1/23/12 **DATE COMPLETED** 1/23/12
GROUND ELEVATION **BORING DEPTH** 24.9 ft.
DRILLING CONTRACTOR Exploration Geoservices, Inc.
LATITUDE **LONGITUDE**
DRILLING METHOD Mobile B-40, 8 inch Hollow-Stem Auger
GROUND WATER LEVELS:
LOGGED BY NBZ
AT TIME OF DRILLING 22 ft.
NOTES
AT END OF DRILLING 22 ft.

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ELEVATION (ft)	DEPTH (ft)	SYMBOL	DESCRIPTION	N-Value (uncorrected) blows per foot	SAMPLES TYPE AND NUMBER	DRY UNIT WEIGHT PCF	NATURAL MOISTURE CONTENT, %	PLASTICITY INDEX, %	PERCENT PASSING NO. 200 SIEVE	UNDRAINED SHEAR STRENGTH, ksf (1.0 2.0 3.0 4.0 5.0)
	0		2 inches asphalt concrete over 2 inches aggregate base and 2 inches Portland cement concrete							
			Lean Clay with Sand (CL) hard, moist, brown, fine to coarse sand, low to moderate plasticity							
			Sandy Lean Clay (CL) very stiff, moist, brown, fine to coarse sand, low to moderate plasticity							
	5			42	MC-1	111	14			HAND PENETROMETER
			Lean Clay with Sand (CL) very stiff, moist, olive brown, fine sand, moderate plasticity							
	10			24	MC-2B	103	20			HAND PENETROMETER
			Liquid Limit = 41, Plastic Limt = 16	40	MC-3B	99	24	25		TORVANE
	15			28	MC-4B	105	21			HAND PENETROMETER
				33	MC-5B	96	26			UNCONFINED COMPRESSION
	20									
			Sandy Lean Clay (CL) medium stiff, wet, olive brown, fine to coarse sand, low to moderate plasticity							
	25		**Clayey Sand (SC)** very dense, wet, grayish brown, fine to medium sand	50 / 5"	MC-6A	109	19			HAND PENETROMETER
			Bottom of Boring at 24.9 feet.							

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BORING NUMBER EB-3

CORNERSTONE EARTH GROUP

PROJECT NAME Sanchez Avenue Sewer Rehab
PROJECT NUMBER 522-1-1
PROJECT LOCATION Burlingame, CA

DATE STARTED 1/23/12 **DATE COMPLETED** 1/23/12
GROUND ELEVATION **BORING DEPTH** 15 ft.
DRILLING CONTRACTOR Exploration Geoservices, Inc.
LATITUDE **LONGITUDE**
DRILLING METHOD Mobile B-40, 8 inch Hollow-Stem Auger
GROUND WATER LEVELS:
LOGGED BY NBZ
AT TIME OF DRILLING Not Encountered
NOTES
AT END OF DRILLING Not Encountered

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ELEVATION (ft)	DEPTH (ft)	SYMBOL	DESCRIPTION	N-Value (uncorrected) blows per foot	SAMPLES TYPE AND NUMBER	DRY UNIT WEIGHT PCF	NATURAL MOISTURE CONTENT, %	PLASTICITY INDEX, %	PERCENT PASSING NO. 200 SIEVE	UNDRAINED SHEAR STRENGTH, ksf (○ HAND PENETROMETER, △ TORVANE, ● UNCONFINED COMPRESSION, ▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL; 1.0 2.0 3.0 4.0 5.0)
	0		3 inches asphalt concrete over 3 inches Portland cement concrete							
			Sandy Lean Clay (CL) very stiff, moist, brown, fine sand, low plasticity							
			Lean Clay with Sand (CL) very stiff, moist, brown, fine to medium sand, low to moderate plasticity	44	MC-1	107	19			○
	5		**Clayey Sand with Gravel (SC)** dense, moist, brown with gray and reddish brown mottles, fine to coarse sand, fine to coarse subangular gravel	51	MC-2B	108	18		27	
				46	MC-3B	118	14			
	10			56	MC-4B	121	13			
				61	MC-5B	117	16		16	
	15		Bottom of Boring at 15.0 feet.							
	20									
	25									

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BORING NUMBER EB-4

CORNERSTONE EARTH GROUP

PROJECT NAME Sanchez Avenue Sewer Rehab
PROJECT NUMBER 522-1-1
PROJECT LOCATION Burlingame, CA

DATE STARTED 1/23/12 **DATE COMPLETED** 1/23/12
GROUND ELEVATION **BORING DEPTH** 20 ft.
DRILLING CONTRACTOR Exploration Geoservices, Inc.
LATITUDE **LONGITUDE**
DRILLING METHOD Mobile B-40, 8 inch Hollow-Stem Auger
GROUND WATER LEVELS:
LOGGED BY NBZ
AT TIME OF DRILLING Not Encountered
NOTES
AT END OF DRILLING Not Encountered

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ELEVATION (ft)	DEPTH (ft)	SYMBOL	DESCRIPTION	N-Value (uncorrected) blows per foot	SAMPLES TYPE AND NUMBER	DRY UNIT WEIGHT PCF	NATURAL MOISTURE CONTENT, %	PLASTICITY INDEX, %	PERCENT PASSING NO. 200 SIEVE
	0		6 inches asphalt concrete						
			Sandy Lean Clay (CL) hard, moist, brown, fine to coarse sand, low to moderate plasticity						
	5			50 / 6"	NR				
	10			37	NR				
			Clayey Sand with Gravel (SC) dense, moist, brown with gray and reddish brown mottles, fine to coarse sand, fine to coarse subangular gravel	48	SPT-1		13		
	15			50	SPT-2		13		
				39	SPT-3		16		38
			Clayey Sand (SC) medium dense, moist, brown with gray and reddish brown mottles, fine to coarse sand, some fine subangular to subrounded gravel	22	SPT-4		17		34
	20		Bottom of Boring at 20.0 feet.						
	25								

UNDRAINED SHEAR STRENGTH, ksf
○ HAND PENETROMETER
△ TORVANE
● UNCONFINED COMPRESSION
▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL
1.0 2.0 3.0 4.0 5.0

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BORING NUMBER EB-5

CORNERSTONE EARTH GROUP

PROJECT NAME Sanchez Avenue Sewer Rehab
PROJECT NUMBER 522-1-1
PROJECT LOCATION Burlingame, CA

DATE STARTED 1/26/12 **DATE COMPLETED** 1/26/12
GROUND ELEVATION **BORING DEPTH** 15 ft.
DRILLING CONTRACTOR Access Soil Drilling, Inc.
LATITUDE **LONGITUDE**
DRILLING METHOD Minuteman, 4 inch Solid Flight Auger
GROUND WATER LEVELS:
LOGGED BY NBZ
AT TIME OF DRILLING Not Encountered
NOTES
AT END OF DRILLING Not Encountered

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ELEVATION (ft)	DEPTH (ft)	SYMBOL	DESCRIPTION	N-Value (uncorrected) blows per foot	SAMPLES TYPE AND NUMBER	DRY UNIT WEIGHT PCF	NATURAL MOISTURE CONTENT, %	PLASTICITY INDEX, %	PERCENT PASSING NO. 200 SIEVE	UNDRAINED SHEAR STRENGTH, ksf (1.0 2.0 3.0 4.0 5.0)
	0		**Lean Clay with Sand (CL) [Fill]** hard, moist, brown with light brown mottles, fine to medium sand, moderate plasticity							
			Lean Clay with Sand (CL) stiff, moist, dark brown, fine to medium sand, moderate plasticity	25	MC-1	90	21			○
	5		**Clayey Sand with Gravel (SC)** dense, moist, brown with gray and reddish brown mottles, fine to coarse sand, fine to coarse subangular gravel	90	MC-2B	106	13			
				65	SPT-3		13			
				35	SPT-4		14			
	10									
				43	SPT-5		16			
	15		Bottom of Boring at 15.0 feet.							
	20									
	25									

UNDRAINED SHEAR STRENGTH, ksf
○ HAND PENETROMETER
△ TORVANE
● UNCONFINED COMPRESSION
▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL

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BORING NUMBER EB-6

CORNERSTONE EARTH GROUP

PROJECT NAME Sanchez Avenue Sewer Rehab
PROJECT NUMBER 522-1-1
PROJECT LOCATION Burlingame, CA

DATE STARTED 1/26/12 **DATE COMPLETED** 1/26/12
GROUND ELEVATION **BORING DEPTH** 15 ft.
DRILLING CONTRACTOR Access Soil Drilling, Inc.
LATITUDE **LONGITUDE**
DRILLING METHOD Minuteman, 4 inch Solid Flight Auger
GROUND WATER LEVELS:
LOGGED BY NBZ
AT TIME OF DRILLING 13 ft.
NOTES
AT END OF DRILLING 8 ft.

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ELEVATION (ft)	DEPTH (ft)	SYMBOL	DESCRIPTION	N-Value (uncorrected) blows per foot	SAMPLES TYPE AND NUMBER	DRY UNIT WEIGHT PCF	NATURAL MOISTURE CONTENT, %	PLASTICITY INDEX, %	PERCENT PASSING NO. 200 SIEVE	UNDRAINED SHEAR STRENGTH, ksf (○ HAND PENETROMETER, △ TORVANE, ● UNCONFINED COMPRESSION, ▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL; 1.0 2.0 3.0 4.0 5.0)
	0		**Lean Clay with Sand (CL) [Fill]** hard, moist, brown with light brown mottles, fine to medium sand, moderate plasticity							
			Lean Clay (CL) stiff, moist, brown, fine to medium sand, moderate plasticity	15	MC-1B	96	25			
	5		**Clayey Sand with Gravel (SC)** dense, moist, dark gray with brown mottles, fine to coarse sand, fine to coarse subangular gravel	43	MC-2B	112	15			
				47	MC					
			Lean Clay with Sand (CL) very stiff, moist, gray with reddish brown and brown mottles, fine to coarse sand, moderate plasticity	19	SPT-4		24			
	10									
			Sandy Lean Clay (CL) stiff, moist to wet, gray with brown mottles, fine sand, low to moderate plasticity	22	MC-5B	103	20			
	15		Bottom of Boring at 15.0 feet.							
	20									
	25									

CORNERSTONE EARTH GROUP - CORNERSTONE.GDT - 2/28/12 13:43 - P:\DRAFTING\GINT FILES\522-1-1 SANCHEZ SEWER REHAB.GPJ

BORING NUMBER EB-7

CORNERSTONE EARTH GROUP

PROJECT NAME Sanchez Avenue Sewer Rehab
PROJECT NUMBER 522-1-1
PROJECT LOCATION Burlingame, CA

DATE STARTED 1/26/12 **DATE COMPLETED** 1/26/12
GROUND ELEVATION **BORING DEPTH** 13.9 ft.
DRILLING CONTRACTOR Access Soil Drilling, Inc.
LATITUDE **LONGITUDE**
DRILLING METHOD Minuteman, 4 inch Solid Flight Auger
GROUND WATER LEVELS:
LOGGED BY NBZ
AT TIME OF DRILLING 6.5 ft.
NOTES
AT END OF DRILLING 10 ft.

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ELEVATION (ft)	DEPTH (ft)	SYMBOL	DESCRIPTION	N-Value (uncorrected) blows per foot	SAMPLES TYPE AND NUMBER	DRY UNIT WEIGHT PCF	NATURAL MOISTURE CONTENT, %	PLASTICITY INDEX, %	PERCENT PASSING NO. 200 SIEVE	UNDRAINED SHEAR STRENGTH, ksf (HAND PENETROMETER ○, TORVANE △, UNCONFINED COMPRESSION ●, UNCONSOLIDATED-UNDRAINED TRIAXIAL ▲; 1.0 2.0 3.0 4.0 5.0)
	0		**Lean Clay with Sand (CL) [Fill]** hard, moist, brown with light brown mottles, fine to medium sand, moderate plasticity							
			Sandy Lean Clay (CL) medium stiff, moist, reddish brown to brown, fine to medium sand, low to moderate plasticity	11	MC-1B	108	19			○
	5			37	MC-2	120	15			
			Clayey Sand with Gravel (SC) medium dense to dense, moist, brown with gray mottles, fine to coarse sand, fine to coarse subangular gravel	65	NR					
			Lean Clay with Sand (CL) hard, moist, brown with gray mottles, fine to medium sand, moderate plasticity	67	MC-3B	105	19			○
	10									
			Clayey Sand with Gravel (SC) very dense, moist, brown, fine to coarse sand, fine to coarse subangular gravel	50 / 5"	MC-4	113	16			
	15		Bottom of Boring at 13.9 feet.							
	20									
	25									

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BORING NUMBER EB-8

CORNERSTONE EARTH GROUP

PROJECT NAME Sanchez Avenue Sewer Rehab
PROJECT NUMBER 522-1-1
PROJECT LOCATION Burlingame, CA

DATE STARTED 2/10/12 **DATE COMPLETED** 2/10/12
GROUND ELEVATION **BORING DEPTH** 21.5 ft.
DRILLING CONTRACTOR Access Soil Drilling, Inc.
LATITUDE **LONGITUDE**
DRILLING METHOD Minuteman, 4 inch Solid Flight Auger
GROUND WATER LEVELS:
LOGGED BY NBZ
AT TIME OF DRILLING Not Encountered
NOTES
AT END OF DRILLING Not Encountered

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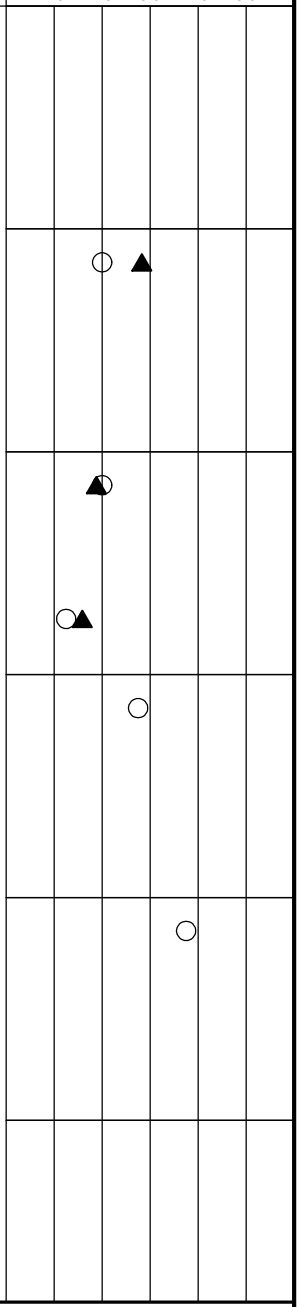
ELEVATION (ft)	DEPTH (ft)	SYMBOL	DESCRIPTION	N-Value (uncorrected) blows per foot	SAMPLES TYPE AND NUMBER	DRY UNIT WEIGHT PCF	NATURAL MOISTURE CONTENT, %	PLASTICITY INDEX, %	PERCENT PASSING NO. 200 SIEVE
	0		4" asphalt concrete						
			Sandy Lean Clay (CL) moist, brown, fine to coarse sand, some fine angular to subangular gravel, low to moderate plasticity						
	5		**Sandy Lean Clay with Gravel (CL)** very stiff, moist, brown with dark brown mottles, fine to coarse sand, fine to coarse angular to subangular gravel, low to moderate plasticity	59	MC				
	10		**Lean Clay with Sand (CL)** very stiff, moist, olive gray with brown mottles, fine to coarse sand, low to moderate plasticity	26	MC				
			Lean Clay (CL) stiff to very stiff, moist, olive gray, low to moderate plasticity	16	MC				
	15			25	MC-4B	103	22		
			Lean Clay with Sand (CL) very stiff, moist, olive gray, fine to medium sand, low to moderate plasticity						
	20			47	MC-5B	110	18		
			Bottom of Boring at 21.5 feet.						
	25								

UNDRAINED SHEAR STRENGTH, ksf
○ HAND PENETROMETER
△ TORVANE
● UNCONFINED COMPRESSION
▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL
1.0 2.0 3.0 4.0 5.0



CORNERSTONE EARTH GROUP - CORNERSTONE.GDT - 2/28/12 13:43 - P:\DRAFTING\GINT FILES\522-1-1 SANCHEZ SEWER REHAB.GPJ

BORING NUMBER EB-9

CORNERSTONE EARTH GROUP

PROJECT NAME Sanchez Avenue Sewer Rehab
PROJECT NUMBER 522-1-1
PROJECT LOCATION Burlingame, CA

DATE STARTED 2/10/12 **DATE COMPLETED** 2/10/12
GROUND ELEVATION **BORING DEPTH** 25 ft.
DRILLING CONTRACTOR Access Soil Drilling, Inc.
LATITUDE **LONGITUDE**
DRILLING METHOD Minuteman, 4 inch Solid Flight Auger
GROUND WATER LEVELS:
LOGGED BY NBZ
AT TIME OF DRILLING Not Encountered
NOTES
AT END OF DRILLING Not Encountered

This log is a part of a report by Cornerstone Earth Group, and should not be used as a stand-alone document. This description applies only to the location of the exploration at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with time. The description presented is a simplification of actual conditions encountered. Transitions between soil types may be gradual.

ELEVATION (ft)	DEPTH (ft)	SYMBOL	DESCRIPTION	N-Value (uncorrected) blows per foot	SAMPLES TYPE AND NUMBER	DRY UNIT WEIGHT PCF	NATURAL MOISTURE CONTENT, %	PLASTICITY INDEX, %	PERCENT PASSING NO. 200 SIEVE	UNDRAINED SHEAR STRENGTH, ksf (1.0 2.0 3.0 4.0 5.0)
	0		9" asphalt concrete							
			Sandy Lean Clay (CL) [Fill] moist, brown, fine to coarse sand,some fine subrounded gravel, low to moderate plasticity							
			Sandy Silty Clay (CL-ML) [Fill] moist, blue gray, fine sand, low to moderate plasticity							
	5		**Sandy Fat Clay with Gravel (CH) [Fill]** soft, moist, blue gray, fine to coarse sand, fine subrounded gravel	7	MC-1B	117	15			○
			Fat Clay (CH) [Bay Mud] soft, moist to wet, blue gray to dark gray, high plasticity	5	MC					◐▲
	10				ST					▲
				3	MC-4B	51	80			○
	15			6	MC-5B	56	67			○
				6	MC-6B	58	65			○
	20									
				9	MC-7B	57	71			○
	25		Bottom of Boring at 25.0 feet.							

○ HAND PENETROMETER
△ TORVANE
● UNCONFINED COMPRESSION
▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL

CORNERSTONE EARTH GROUP - CORNERSTONE.GDT - 2/28/12 13:43 - P:\DRAFTING\GINT FILES\522-1-1 SANCHEZ SEWER REHAB.GPJ

APPENDIX B: LABORATORY TEST PROGRAM

The laboratory testing program was performed to evaluate the physical and mechanical properties of the soils retrieved from the site to aid in verifying soil classification.

Moisture Content: The natural water content was determined (ASTM D2216) on 43 samples of the materials recovered from the borings. These water contents are recorded on the boring logs at the appropriate sample depths.

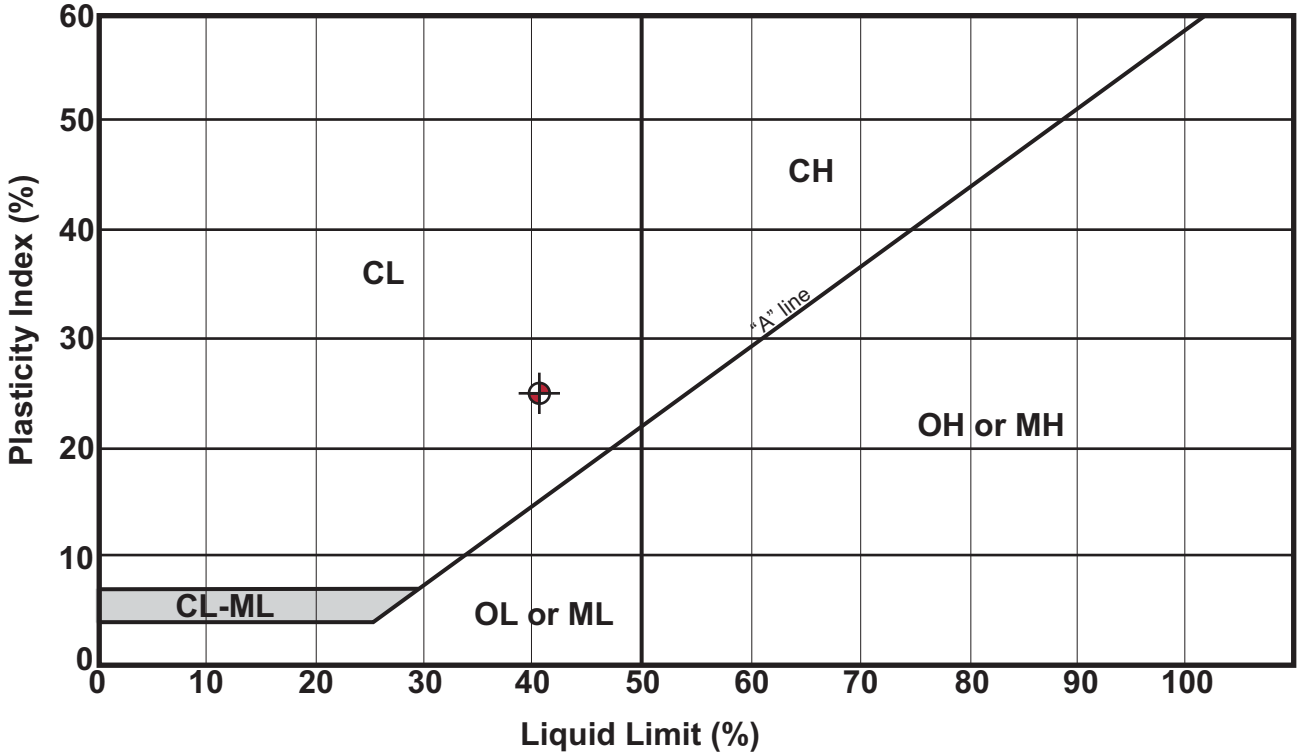
Dry Densities: In place dry density determinations (ASTM D2937) were performed on 33 samples to measure the unit weight of the subsurface soils. Results of these tests are shown on the boring logs at the appropriate sample depths.

Washed Sieve Analyses: The percent soil fraction passing the No. 200 sieve (ASTM D1140) was determined on 4 samples of the subsurface soils to aid in the classification of these soils. Results of these tests are shown on the boring logs at the appropriate sample depths.

Plasticity Index: One Plasticity Index determination (ASTM D4318) was performed on a sample of the subsurface soil to measure the range of water contents over which this material exhibits plasticity. The Plasticity Index was used to classify the soil in accordance with the Unified Soil Classification System and to evaluate the soil expansion potential. Results of this test are shown on the boring log at the appropriate sample depth.

Undrained-Unconsolidated Triaxial Shear Strength: The undrained shear strength was determined on seven relatively undisturbed sample(s) by unconsolidated-undrained triaxial shear strength testing (ASTM D2850). The results of this test are included as part of this appendix.

Plasticity Index (ASTM D4318) Testing Summary



Symbol	Boring No.	Depth (ft)	Natural Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Passing No. 200 (%)	Group Name (USCS - ASTM D2487)
⊕	EB-2	13.5	24	41	16	25	—	Lean Clay with Sand (CL)

CORNERSTONE EARTH GROUP

Plasticity Index Testing Summary

Sanchez Avenue Sewer Rehab.
Burlingame, CA

Project Number: 522-1-1

Figure Number: Figure B1

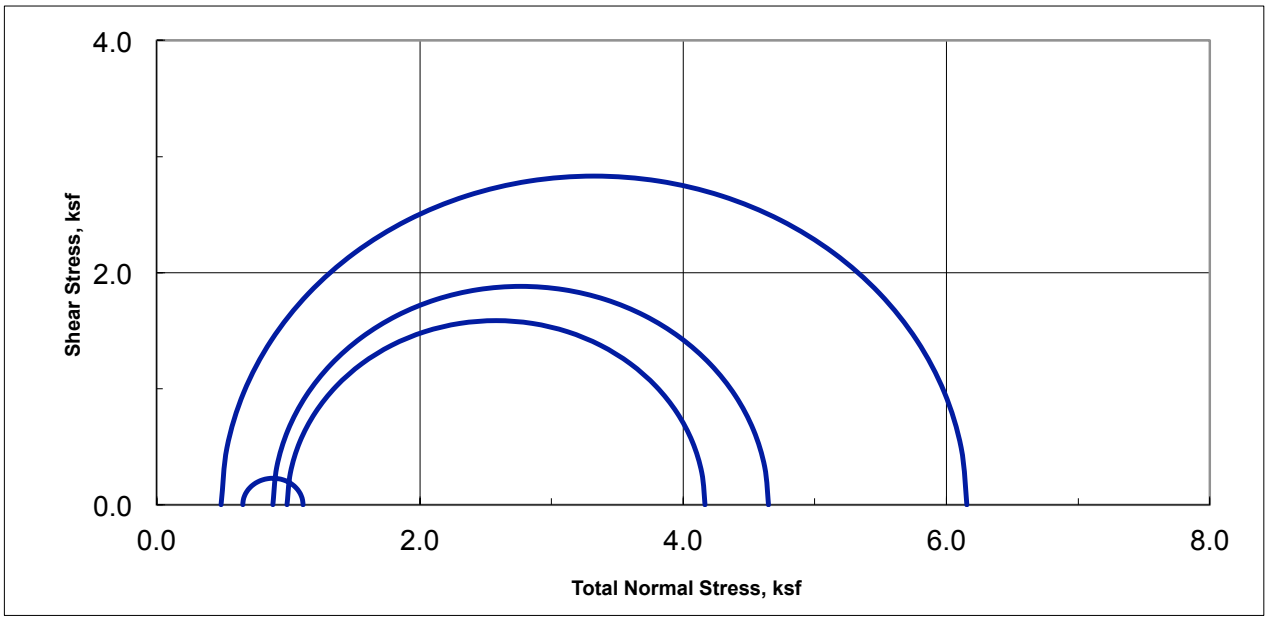
Date: February 2012

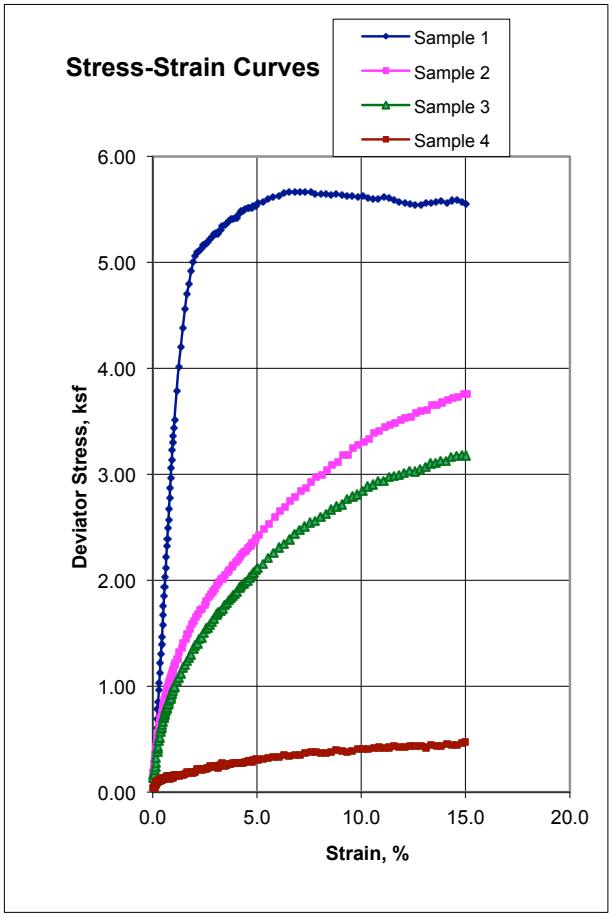
Drawn By: FLL

Cooper Testing Labs, Inc.
937 Commercial Street
Palo Alto, CA 94303

Unconsolidated-Undrained Triaxial Test

ASTM D-2850





Sample Data				
	1	2	3	4
Moisture %	13.6	23.1	20.0	92.8
Dry Den,pcf	118.3	103.5	109.0	47.6
Void Ratio	0.425	0.628	0.546	2.545
Saturation %	86.4	99.5	98.7	98.5
Height in	5.02	5.01	5.00	4.99
Diameter in	2.42	2.40	2.40	2.40
Cell psi	3.4	6.1	6.9	4.5
Strain %	7.00	14.90	14.80	15.00
Deviator, ksf	5.668	3.763	3.184	0.469
Rate %/min	1.00	1.00	1.01	1.01
in/min	0.050	0.050	0.050	0.050
Job No.:	**640-369a**			
Client:	**Cornerstone Earth Group**			
Project:	**Sanchez Ave. Sewer Rehab. - 522-1-1**			
Boring:	EB-8	EB-8	EB-8	EB-9
Sample:	1B	2B	3B	2B
Depth ft:	6.0	11	14.0	9.5

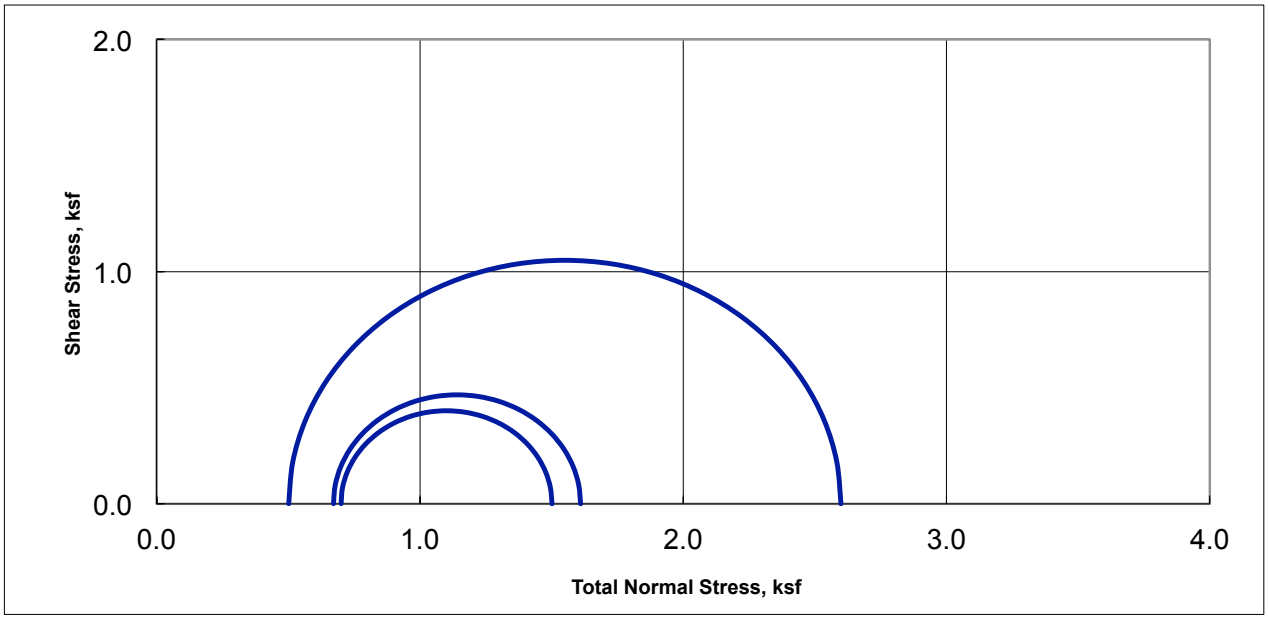
Visual Soil Description	
Sample #	
1	Strong Brown Clayey SAND w/ Gravel
2	Strong Brown CLAY w/ Sand
3	Dark Yellowish Brown Sandy CLAY
4	Very Dark Bluish Gray CLAY w/ organics

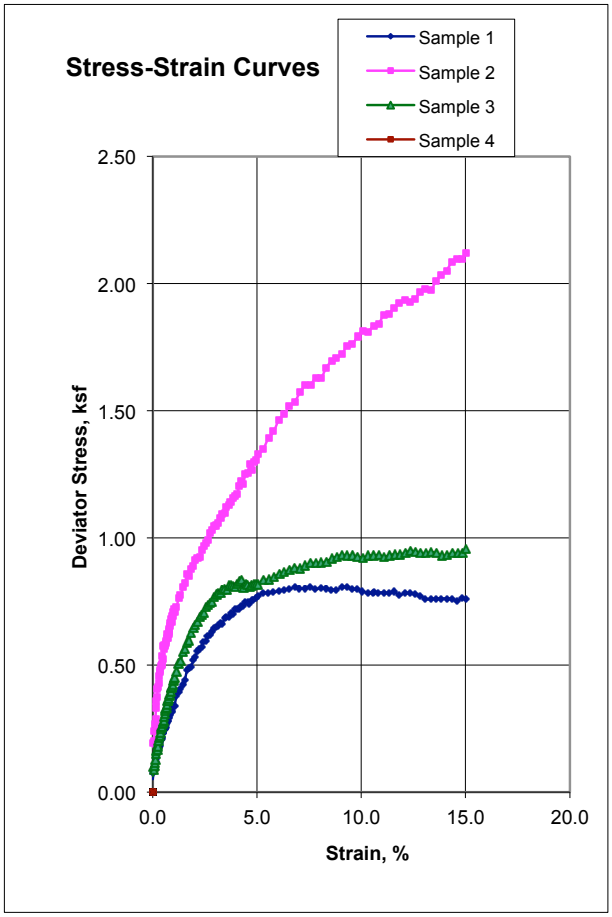
Remarks:

Cooper Testing Labs, Inc.
937 Commercial Street
Palo Alto, CA 94303

Unconsolidated-Undrained Triaxial Test

ASTM D-2850





Sample Data				
	1	2	3	4
Moisture %	84.9	11.3	81.5	
Dry Den,pcf	50.9	118.0	52.1	
Void Ratio	2.310	0.428	2.236	
Saturation %	99.3	71.1	98.4	
Height in	5.99	5.02	5.99	
Diameter in	2.86	2.36	2.87	
Cell psi	4.9	3.5	4.7	
Strain %	7.50	15.00	15.00	
Deviator, ksf	0.807	2.122	0.957	
Rate %/min	1.00	1.19	1.00	
in/min	0.060	0.060	0.060	
Job No.:	**640-369b**			
Client:	**Cornerstone Earth Group**			
Project:	**Sanchez Ave. Sewer Rehab. - 522-1-1**			
Boring:	EB-9	EB-10	EB-10	
Sample:	3	1	3	
Depth ft:	10-13	6.0	10	

Visual Soil Description	
Sample #	
1	Dark Bluish Gray CLAY (Bay Mud)
2	Dark Olive Brown Clayey SAND w/ Gravel
3	Very Dark Bluish Gray CLAY (Bay Mud)
4	

Remarks:

APPENDIX C

GUIDELINES FOR CONSTRUCTION ON BAY MUD SITES

INTRODUCTION

Constructing improvements on the Bay Margin presents difficulties throughout the Bay Area. These general guidelines are meant to provide a general understanding of some of the difficulties working in such an environment, where conditions likely include fill material, soft, saturated, weak clays, and shallow ground water. These general guidelines should be used as a supplement to the construction plans and specifications for the project.

GENERAL SOIL AND GROUND WATER CONDITIONS

As discussed in the geotechnical report, the entire site area was once a tidal marsh of the San Francisco Bay with possible meandering sloughs running through the site. Historically, the area was diked and cleared, and fills were placed across the site area at different times. The fill in the area is generally 8 to 9 feet in thickness and generally consists of low permeability, moderately plastic, sandy lean clay and clayey sand.

The fill is underlain by native soft, marine clays, known locally as Bay Mud. In general, the upper 3 to 5 feet is somewhat desiccated, and therefore stiffer than the underlying mud, and is often referred to as Bay Mud crust. Below the crust, the clays are saturated, soft, weak, and highly compressible. Moisture contents of the crust material are generally in the 35 to 70 percent range, and moisture contents for the underlying clays are generally in the 70 to 95 percent range.

The soft, compressible Bay Mud is generally underlain by older bay clays that are generally very stiff to hard and of low compressibility.

Ground water is generally assumed to be near the top of Bay Mud; however, ground water does not typically appear quickly as free water, but does seep out of the mud slowly – often from more highly permeable seams of silts or fine sands. Since Bay Mud was deposited in a marine environment, and the ground water will often be brackish. Ground water is seasonally also found to perch in the upper fill materials above the top of Bay Mud.

UNSTABLE SOIL CONDITIONS

During construction on Bay Mud sites, often due to regular construction traffic or compaction during grading, the surface soils or exposed subgrade become unstable. Bay Mud sites are particularly susceptible to instability because of the perched water frequently encountered at these sites, and the soft underlying clays. Unstable areas can be difficult to stabilize on Bay Mud sites, and likely required crushed rock and stabilization fabric or geogrid, or other approved methods.

HEAVY EQUIPMENT LIMITATIONS

As discussed, soft clays generally underlie the entire site. For this reason, construction equipment should be limited to medium to lightweight equipment to reduce the potential for instability, damage to shallow utilities, or slope failures. Instability is a significant issue on Bay Mud sites, and often leads to extra efforts to stabilize materials, dry out wet materials, and achieve compaction. The use of heavy equipment will greatly exacerbate this issue. We have the following general guidelines to aid in choosing the appropriate equipment for the site. Where lighter equipment can not be used, such as during pile installation, then extra care and support efforts will be required to traffic the heavy equipment across the site.

1. Avoid the use of heavy equipment on the site. This includes heavy vehicles – we generally recommend vehicles less than 15 tons – and vehicles with heavy point loads, such as forklifts or other types of lifts.

2. Where fill materials have been partially removed, the exposed soils will be even more susceptible to instability, and we recommend that lighter weight equipment be used in these situations. We do not recommend direct vehicles loads of any kind on exposed Bay Mud.

3. Moderate to heavy equipment should not come close to any excavation in Bay Mud, and should generally stay at least 3 to 4 times the height of the excavation from the edge of the excavation.

4. Traffic routes should be well-prepared and smooth to avoid bouncing of vehicles. Traffic speed should be kept low.

5. Shallow utilities should be located and protected from vehicle loading.

UTILITY CONSIDERATIONS

Bay Mud sites present several significant risks to shallow utilities. The most significant risk to shallow utilities on Bay Mud site is typically damage due to vehicle loading. Traffic loading can cause deflections and rutting, and can also significant load a utility where shallow cover exists, damaging the utility. In addition, construction means, methods and materials that are not appropriate for Bay Mud sites, and do not take into account the site conditions, can also distress utilities. We suggest the follow guidelines be considered.

1. Shallow utilities should be protected from traffic loading and properly marked during construction. Protection might include slurry or lean concrete cover, trench plates, soil mounding, or other approved methods.

2. Construction equipment should not be allowed to traverse utilities where deflections or rutting is occurring, or subgrade soils are unstable. Properly designed access roads and utility protection should be implemented.

3. Distress to utilities can often not be discovered until much later; therefore, precautionary steps should be taken prior to allowing traffic to cross shallow utilities.

4. The backfill of utilities extending into Bay Mud may need to include lightweight backfill materials to limit backfill weights relative to the weight of material removed. Otherwise, settlement of the underlying Bay Mud may be induced causing sags in the utility.

5. Excavations in Bay Mud for utilities require shoring in most cases. We recommend against the use of trench shields unless special precautions are used during installation and extraction to limit deflections and deformation of the underlying Bay Mud. For example, dragging a trench shield along the trench would not be allowed. In addition, voids between excavation sidewalls and trench shields could allow lateral creep or sloughing of native soils.

OPEN EXCAVATIONS AND TRENCHES

Open excavations and trenches in Bay Mud require special precautions to prevent failures and potentially distress other improvements or cause significant delays and cost to the project. Contractors should carefully review the site conditions and preferably have experience in working on Bay Mud. We suggest the following guidelines be considered.

1. Trench excavations in Bay Mud or in fills overlying Bay Mud may be subject to failure and/or collapse due to the weak strength of Bay Mud. Equipment or stockpiles near excavations can also cause failures. All excavations and trenches should be properly shored or sloped back at an appropriate inclination.

2. Even shored excavations should be checked for potential failure mechanisms such as bottom heave prior to excavation and installation of shoring. The stability of all excavations and shoring should be the contractor's responsibility.

3. Glory hole excavations and large v-trenching should not be backfilled with heavy import materials as detrimental settlement is likely to occur. Backfill materials should be similar in weight to the weight of materials removed.

4. Excavations extending into Bay Mud should have fill materials and Bay Mud segregated during excavation. Most contractors accomplish this by putting fill material on one side of the trench and Bay Mud on the other. Bay Mud is typically removed from the site because re-use would require a considerable amount of processing and drying to reach optimum moisture content for re-use as engineered fill.

5. Shallow trenches that extend into Bay Mud crust may remain open temporarily during utility installation – at the contractor's risk. However, trenches that extend into Bay Mud should be backfilled as soon as possible to prevent failures or instability of the sidewalls.

6. The contractor should completely review the geotechnical report and these guidelines in addition to the project plans and specifications to understand the difficulties of working on a Bay Mud site.

SOIL AND AGGREGATE STOCKPILES

Stockpiling soil and crushed concrete and asphalt can cause non-uniform compression or bearing failure of the underlying Bay Mud. Stockpiles should be 5 feet or less in height. In addition, stockpiles should not be left in place for long periods (weeks) at a time. The Geotechnical Engineer should review and approve the proposed location and lateral extent of soil stockpiles greater than 5 feet high prior to construction.