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File: 216003
February 11, 2016

Mr. Mike O'Connell
900 Rosita Road
Pacifica, CA 94044

Subject: **San Pedro Terrace Road Property**
Off the west end of San Pedro Terrace Road
Pacifica, California
GEOTECHNICAL INVESTIGATION FOR PROPOSED NEW RESIDENTIAL SUBDIVISION OR ONE COMMERCIAL BUILDING

Dear Mr. O'Connell:

In accordance with your authorization, we have performed a subsurface investigation into the geotechnical conditions present at the location of the proposed improvements. This report summarizes the conditions we measured and observed, and presents our opinions and recommendations for the design and construction of the proposed new six-lot residential subdivision or one commercial building.

Site Description

The subject site is a relatively level, irregularly-shaped parcel located off the west end of San Pedro Terrace Road (at the approximate location shown on Figure 1). The property is bounded by a shallow approximately 5 feet deep creek channel to the north, undeveloped areas to the south and west, a commercial building to the east, and San Pedro Terrace Road to the southeast. The site is currently an undeveloped lot overgrown with small to medium bushed, small to large trees, and various native plants and pampas grasses. An asphalt pathway from the end of San Pedro Terrace Road continues south of the property, with a portion of the walkway extending up towards the southern perimeter of the property.

The ground surface in the site vicinity has an overall slope down towards the west (as shown on Figure 2). At the site, the ground slopes gently down towards the south and west. Surface gradients range from level to 20:1 (horizontal:vertical, H:V). During the original development of the property, it appears that at least 5.5 feet of fills were placed in order to create the existing level pad.

Proposed Construction

We understand that the current development for the site proposes the construction of six new single family residences or one commercial building. The houses or commercial building are to be of conventional, wood-framed construction. New foundation loads are expected to be typical for these types of structures (i.e. light).

Excavation work at the site is expected to be limited to crawlspace and foundation excavations. No significant fill placement is anticipated as part of this work. No significant retaining walls are anticipated for this scope of work. No basements or pools are planned for the project.

INVESTIGATION

Scope and Purpose

The purpose of our investigation was to determine the nature of the subsurface soil conditions so that we could provide geotechnical recommendations for the construction of the proposed new residences or commercial building. In order to achieve this purpose, we have performed the following scope of work:

1 - visited the property to observe the geotechnical setting of the area to be developed;
2 - reviewed relevant published geotechnical maps;
3 - reviewed relevant historical aerial photos;
4 - drilled four borings near the location of the proposed improvements;
5 - performed laboratory testing on collected soil samples;
6 - assessed the collected information and prepared this report.

The findings of these work items are discussed in the following sections of this report.

Site Observations

We visited the site on January 8, 2015 to observe the geotechnically relevant site conditions. During our visit, we noted the following conditions:

A - An asphalt walkway forms a “cul-de-sac” south of the property. We observed hairline to ¼ inch wide cracks in the asphalt walkway.

B - We would characterize the drainage on the lot to be sheet flow to the south and west. However, marshy ground surface and some puddling due to recent rains, was observed over portions of the lot.

Geologic Map Review

We reviewed the *Geology of the Onshore Part of San Mateo County, California: Derived from the Digital Database Open-File 98-137*, by Earl E. Brabb, R.W. Graymer, and D.L. Jones (1998). The relevant portion of the Brabb, Graymer, and Jones map has been reproduced in Figure 3.

The Brabb, Graymer, and Jones map indicate that the site is underlain by Younger (outer) Alluvial Fan Deposits (map symbol “Qyf”), and on the border of Artificial Fill (map symbol “af”).

The Younger Alluvial Fan Deposits have been described as consisting of "unconsolidated fine sand, silt, and clayey silt."

Artificial Fill has been described as consisting of "loose to very well consolidated gravel, sand, silt, clay, rock fragments, organic matter, and man-made debris in various combinations. Thickness is variable and may exceed 30 meters in some places. Some is compacted and quite firm, but fill made before 1965 is nearly everywhere not compacted and consists simply of dumped materials."

In the western two-thirds of the property (Borings 1 and 2), our subsurface exploration (see below) encountered some artificial fill materials, over clay and sand materials which we judged to be consistent with the Younger Alluvial Fan Deposit mapping. In the eastern one-third of the property, our borings (Borings 3 and 4) encountered clay and sand materials we judged to be consistent with the Younger Alluvial Fan Deposits.

The active San Gregorio Fault is mapped approximately 1.7 miles (2.7 km) southwest of the site.

Previous Grading Work

During review of historic photos of the subject site, it appears some grading work has been performed in the past. No documentation of this grading work was found at the Pacifica building or engineering departments.

We reviewed aerial photos from Google Maps dated July 1993, October 2002, May 2003, December 2003, and September 2004. Photos suggest that some grading work was performed just prior to October 2002 to after December 2003. By September 2004, the site grades appear to be more or less they do does today.

Subsurface Exploration

On January 8, 2016 we drilled four borings at the site at the locations shown on Figure 4. The borings were drilled using a Mobile B-24 truck-mounted drilling rig and a Minute Man portable drilling rig (as noted on logs) equipped with 4.0 inch diameter, helical flight augers. Logs of the soils encountered during drilling record our observations of the cuttings traveling up the augers and of relatively undisturbed samples collected from the base of the advancing holes. The final boring logs are based upon the field logs with occasional modifications made upon further laboratory examinations of the recovered samples and laboratory test results. The final logs are attached in Appendix A.

The relatively undisturbed samples were obtained by driving a 3.0 inch (outer diameter) Modified California Sampler and a Standard Penetration Sampler (as noted on logs) into the base of the advancing hole by repeated blows from a 140 pound hammer lifted 30 inches. On the logs, the number of blows required to drive the sampler the final 12 inches of the 18 inch drive, have been recorded as the Blow Counts. These blows <u>have not</u> been adjusted to reflect equivalent blows of any other type of sampler or hammer, or to account for the different samplers used.

Subsurface Conditions

Boring 1 first penetrated 3.5 feet of firm silty clay with sand and gravels over a 1 foot layer of gravels. At 4.5 feet, the boring encountered stiff fine sandy silt which graded to a firm silty clay by a depth of 11 feet. At 14.5 feet, the boring encountered gravelly coarse sand down to the terminated boring depth of 17.5 feet.

Boring 2 penetrated 5.5 feet of silty clay and sand with varying amounts of gravel and broken up pieces of concrete (fill). This fill was underlain by firm to stiff silt with varying amounts of sand, decomposed granite, and rock fragments to a depth of 15.5 feet. Below this was silty sandy clay which graded to a silty sand with decomposed granite and some clay by a depth of 18 feet. At 19 feet, the boring encountered firm silty clay down to the terminated boring depth of 19.5 feet.

Borings 3 and 4 encountered stiff silty clay with varying amounts of sand, gravel, decomposed granite, and rock fragments down to the terminated boring depths of 13.5 and 15.5 feet.

Please refer to Appendix A for a more detailed description of each boring.

Initially, groundwater was encountered at depths of 14.5 feet (Boring 1 and Boring 2), 10 feet (Boring 3), and 11.5 feet (Boring 4) during the drilling of the holes. In Boring 1, the level of the water rose to a depth of 13.5 feet after approximately 2.5 hours. In Boring 2, the level of the water rose to 13.5 feet after 1.5 hours. In Boring 2, the level of the water rose to 11 feet after 1 hour. However, during periods of heavy rain or late in the winter, groundwater seepage may exist at even shallower depths.

Laboratory Testing

The relatively undisturbed samples collected during the drilling process were returned to the laboratory for testing of engineering properties. In the lab, selected soil samples were tested for moisture content, density, 200 sieve wash, strength, and plasticity. The results of the laboratory tests are attached to this report in Appendix B.

A Sieve Analysis performed on a sample of the site materials (Sample 1-4 @ 17 feet) showed the tested materials are composed of 17.5 percent gravel, 62.9 percent sand, and 19.6 percent silt and clay. This would indicate that there is low to moderate gravel content, and a moderately high fines content, which could be potentially subject to liquefaction.

Strength testing was conducted on a sample of the near surface material (Sample 2-2 @ 9 feet). The testing showed that this material has moderate strength parameters (cohesion = 600 psf, friction angle = 20.6 degrees). The other deeper soils at the site were judged to also have moderate strengths based upon their higher blow counts as obtained during the sampling process.

Plasticity Index (PI) testing performed on the site near surface materials produced a PI result of 12. This testing indicated that the near surface materials have low plasticity and are of low expansion potential.

CONCLUSIONS AND RECOMMENDATIONS

General

Based upon our investigation, we believe that the proposed improvements can be safely constructed. Geotechnical development of the site is controlled by the presence of undocumented fills, and a layer of potentially liquefiable soils between approximately 8 to 15 feet below existing grades. Therefore, it will be necessary to utilize a foundation system which derives its support from the deeper, more stable soils beneath the liquefiable soils or use a stiff foundation system and accept some overall tilt of the structure. We recommend a waffle be utilized under a mat slab if tilting is acceptable due to liquefaction. This solution would work best for smaller structures, such as residences or a small commercial building.

If used, we anticipate that pier depths would need to be on the order of 25 feet or greater.

The recommendations in this report should be incorporated into the design and construction of the proposed new residences or commercial building.

Seismicity

The greater San Francisco Bay Area is recognized by Geologists and Seismologists as one of the most active seismic regions in the United States. Several major fault zones pass through the Bay Area in a northwest direction which have produced approximately 12 earthquakes per century strong enough to cause structural damage. The faults causing such earthquakes are part of the San Andreas Fault System, a major rift in the earth's crust that extends for at least 700 miles along western California. The San Andreas Fault System includes the San Andreas, San Gregorio, Hayward, Calaveras Fault Zones, and other faults.

During 1990, the U.S. Geological Survey cited a 67 percent probability that an earthquake of Richter magnitude 7, similar to the 1989 Loma Prieta Earthquake, would occur on one of the active faults in the San Francisco Bay Region in the following 30 years. Recently, this probability was increased to 70 percent, as a result of studies in the vicinity of the Hayward Fault. A 23 percent probability is still attributed specifically to the potential for a magnitude 7 earthquake to occur along the San Andreas Fault by the year 2020.

Ground Rupture - The lack of mapped active fault traces through the site, suggests that the potential for primary rupture due to fault offset on the property is low.

Ground Shaking - The subject site is likely to be subject to very strong to violent ground shaking during its life span due to a major earthquake in one of the above-listed fault zones. Current (2013) building code design may be followed by the structural engineer to minimize damages due to seismic shaking, using the following input parameters from the USGS Java Ground Motion Parameter Calculator based upon ASCE 7-10 design parameters:

Site Class - D	$SM_S = 2.154$	$SM_1 = 1.383$	$SD_S = 1.436$	$SD_1 = 0.922$

Landsliding - We note that the subject site and the surrounding area are generally level. Therefore, the hazard due to seismically-induced landsliding is, in our opinion, very low for the site.

Liquefaction - Liquefaction most commonly occurs during earthquake shaking in loose fine sands and silty sands associated with a high ground water table. Our subsurface investigation encountered materials located at depth of about 6 to 15 feet that would be potentially subject to liquefaction during a major earthquake, although only the soils from 13.5 to 15 feet were saturated. In addition, studies have found that when liquefiable soils are covered by at least 10 feet (3 meters) of non-liquefiable soils, the impacts of the liquefaction tend to be regional movements, rather than more dramatic localized problems. Although liquefaction is unlikely to have a significant effect on the subject property, the proposed rigid foundation should help to minimize any movements even further. Therefore, it is our opinion that the potential for any severe damages or collapse due to liquefaction at the site are low with the proper foundations for small structures. Larger structures (e.g. commercial buildings) would require compaction grouting.

Ground Subsidence - Ground subsidence may occur when poorly consolidated soils densify as a result of earthquake shaking. Since the proposed building site is underlain at shallow depths by resistant materials, the hazard due to ground subsidence is, in our opinion, considered to be low.

Lateral Spreading - Lateral spreading may occur when a weak layer of material, such as a sensitive silt or clay, loses its shear strength as a result of earthquake shaking. Overlying blocks of competent material may be translated laterally towards a free face. Free face conditions are not present proximate to the site, hence, the hazard due to lateral spreading is, in our opinion, considered to be low.

Site Preparation and Grading

All debris resulting from the demolition of existing improvements should be removed from the site and may not be used as fill. Any existing underground utility lines to be abandoned should be removed from within the proposed building envelope and their ends capped outside of the building envelope.

Any vegetation and organically contaminated soils should be cleared from the building area. All holes resulting from removal of tree stumps and roots, or other buried objects, should be overexcavated into firm materials and then backfilled and compacted with native materials.

The placement of fills at the site is expected to include: utility trench backfill, slab subgrade materials, and finished drainage and landscaping grading. These and all other fills should be placed in conformance with the following guidelines:

Fills may use organic-free soils available at the site or import materials. Import soils should be free of construction debris or other deleterious materials and be non-expansive. *A minimum of 3 days prior to the placement of any fill, our office should be supplied with a 30 pound sample (approximately a full 5 gallon bucket) of any soil or baserock to be used as fill (including native and import materials) for testing and approval.*

All areas to receive fills should be stripped of organics and loose or soft near-surface soils. Fills should be placed on <u>level</u> benches in lifts no greater than 6 inches thick (loose) and be compacted to at least 90 percent of their Maximum Dry Density (MDD), as determined by ASTM D-1557. In pavement (concrete or asphalt) areas to receive vehicular traffic, all baserock materials should be compacted to at least 95 percent of their MDD. Also, the upper 6 inches of soil subgrade beneath any pavements should be compacted to at least 95 percent of its MDD.

Commercial Building – Due to the undocumented fills at the site, we recommend the upper 5 feet of site materials beneath the building pad of any proposed commercial building be overexcavated and recompacted as a uniform engineered fill if the building will not be pier supported.

Temporary, dry-weather, vertical excavations should remain stable for short periods of time to heights of 5 feet. All excavations should be shored or sloped in accordance with OSHA standards. Cuts deeper than 10 feet may encounter groundwater and will require temporary (and perhaps permanent) dewatering.

Permanent cut and/or fill slopes should be no steeper than 2:1 (H:V). However, even at this gradient, minor sloughing of slopes may still occur in the future. Positive drainage improvements (e.g. drainage swales, catch basins, etc.) should be provided to prevent water from flowing over the tops of cut and/or fill slopes.

<u>Compaction Grouting</u>

As discussed above, at least a portion of the native soil deposits beneath the site are potentially subject to liquefaction during strong earthquake shaking. If the commercial building will not be supported on a drilled pier foundation, then we recommend the zone between 10 to 15 feet below existing grades be remediated. In order to reduce the potential for liquefaction and consolidation to affect the proposed commercial building, we recommend that the soils beneath and around any proposed commercial building be densified and strengthened through a program of grouting. Compaction, pressure, chemical, or other methods of soil grouting or mixing may be considered.

However, the resulting product should improve the soil strength/resistance for a distance of at least 15 feet beneath the base of the proposed new footings. The limits of grouting should extend at least 8 feet beyond the building envelope of the proposed commercial building. The exact methodology of grouting may be developed by the specialty contractors who do this work, though should be approved by our office. We recommend that The Pressure Grout Company (510-887-2244), SCC Technology (650-349-4460), or similar soil grouting/mixing contractor be contacted. Once the weak soils beneath the proposed commercial building area has been improved, the proposed new commercial building may be constructed in conformance with the recommendations of the following sections of this report. *Any area which is not grouted may be potentially subject to liquefaction-induced ground settlements.*

Residential Foundations (Lots 1 through 3) – Spread Footings

Due to the relatively non-expansive nature of the site materials and low liquefaction potential in the area of the site, the foundations for houses on the three eastern lots (lots 1 through 3) may consist of conventional spread footings.

All footings should be a minimum of 15 inches wide. Strip footings should be embedded a minimum of 24 inches below exterior grade and 18 inches below interior grade, *whichever is deeper*. Stepped footings need only be embedded 18 inches below exterior grade at the toe. Isolated footings (e.g. interior pads or exterior post supports) should be embedded at least 24 inches below lowest adjacent grade.

All footings should bear on competent materials, as verified by our office in the field. Localized deepening of footings may be required to reach the competent materials.

The footings should be founded below an imaginary line projecting at a 1:1 slope from the base of any adjacent, parallel utility trenches. The footings must be embedded so that there is a minimum of 20 feet of horizontal cover between the face of the footings and any adjacent, parallel slope.

The footings should be designed to exert pressures on the ground, which do not exceed 2500 psf for Dead plus Live Loads. The weight of the embedded portion of the footings may be neglected when determining bearing pressures. Lateral pressures may be resisted by friction between the base of the footings and the ground surface. A friction coefficient of 0.35 may be assumed. Alternatively, lateral pressures may be resisted by a passive pressure of 350 pcf EFW assumed to be acting against the face of the footings (or shear keys, if required). These values may be increased 1/3 for transient loads (i.e. seismic and wind).

Footings should be nominally reinforced with four #4 bars (two at top and two at bottom). The designer should determine actual width, embedment and reinforcement for the footings.

If the above recommendations are followed, total foundation settlements should be less than 1 inch, while differential settlements should be less than ¾ inches.

Commercial Building and House Foundation of Lots 4 through 6 – Waffle System

The foundations for a smaller commercial building, or the houses on lots 4 through 6 should consist of a series of interlocking grade beams which will create a rigid mat upon which the new structures may be constructed. To provide the most rigid system, it will be important that long, narrow protrusions be minimized from the design in favor of the most rectangular (ideally square) footprint geometry possible. It should be noted that use of a waffle system may still result in differential settlements relative to the grades surrounding the residences or commercial building, resulting in elevation differences across building/residence entrances and thresholds, as well as an overall tilt to the structures as a result of major earthquake inducing liquefaction.

The grade beams should be capable of spanning or cantilevering the following distances and amounts:

Settlements - 3 inches over 20 foot diameter area anywhere in the interior; 10 feet of lost support along the perimeter; and, 10 feet of lost support at any corner.

The movements under the foundations must not result in a deflection of the foundation grade beam system in excess of a ratio of 1:360. To achieve this rigidity, it is anticipated that foundation grade beams will need to be on the order of 2 to 3 feet tall, a minimum of 18 inches wide, and spaced at no more than 15 feet in any direction. Ideally, grade beams should be located under all interior walls so as to maximize the rigidity under these walls.

The grade beams will all need to bear on stiff soils as identified by our office in the field. The grade beam system may be designed for a higher than normal bearing capacity, as bearing capacity failures would actually assist in limiting deflections for such a structure. In this case, a bearing capacity of 3000 psf may be used.

For resistance to lateral forces, the embedded faces of the grade beams may be assumed to develop a passive resistance of 200 psf.

Commercial Building Foundations – Piers

Due to the presence of potentially liquefiable site soils, the foundations will need to penetrate into the deeper, more stable soils. We recommend a pier and grade beam foundation system be used.

Piers should penetrate a minimum of 25 feet below lowest adjacent grade. The piers should have a minimum diameter of 16 inches and be nominally reinforced with a minimum of four #4 bars vertically. Piers should be spaced a maximum of 10 feet center to center.

Holes greater than 10 feet may encounter groundwater. The contractor should be prepared to tremmie the piers, drill and pour the piers, and/or case the piers in the event of caving.

Actual pier depth, diameter, reinforcement, and spacing should be determined by the structural engineer based upon the following design criteria:

A friction value of 500 psf may be assumed to act on that portion of the pier below a depth of 15 feet. Lateral support may be assumed to be developed along the length of the pier below 15 feet, using a passive pressure of 350 pcf Equivalent Fluid Weight (EFW). Passive resistance may be assumed to act over 1.5 projected pier diameters. Above 15 feet, no frictional or lateral support may be assumed. These design values may be increased 1/3 for transient loads (i.e. seismic and wind).

The upper 15 feet of the pier may experience down drag as a result of liquefaction. We recommend that a down drag friction of 500 psf be used on the upper 10 feet of pier.

Even though piers are designed to derive their vertical resistance through skin friction, the bases of the piers holes should be clean and firm prior to setting steel and pouring concrete. If more than 6 inches of slough exists in the base of the pier holes after drilling, then the slough should be removed. If less than 6 inches of slough exists, the slough may be tamped to a stiff condition. Piers should not remain open for more than a few days prior to casting concrete. In the event of rain, shallow groundwater, or caving conditions it may be necessary to pour piers immediately.

All perimeter piers, and piers under load-bearing walls, should be connected by concrete grade beams. Perimeter grade beams should penetrate a minimum of 6 inches below crawlspace grade (unless a perimeter footing drain is installed to intercept water attempting to enter around the perimeter). Interior grade beams do not need to penetrate below grade.

All improvements connected directly to any pier supported structure, also need to be supported by piers. This includes, but is not limited to: porches, decks, entry stoops and columns, etc. If the designer does not wish to pier support these items, then care must be taken to structurally isolate them (with expansion joints, etc.) from the pier supported structure.

If the above recommendations are followed, total foundation settlements should be less than 1 inch, while differential settlements should be less than ½ inches.

Retaining Walls

No new retaining walls are proposed for this scope of work. If plans should change to include retaining walls, then our office should be contacted for additional recommendations.

<u>Ratproofing</u>

To minimize moisture changes in the soils, we recommend the new crawlspaces be covered by a 2 inch thick layer of concrete ratproofing underlain by a 15 mil vapor barrier (e.g. Stego Wrap). The vapor barrier should be placed as soon as the crawlspace subgrade is exposed in order to limit moisture loss during construction. The rat slab may be placed at any time prior to floor joist installation. It would be prudent to slope the subgrade or top of ratproofing to a low area where any trapped water can drain through the foundation to the perimeter footing drain.

<u>Slabs-on-Grade</u>

Lots 1 through 3 Residential Slabs - The house floors should not consist of concrete slabs-on-grade, structural slabs are acceptable, or raised wood floors.

Lots 4 through 6 Residential Slabs - The house floors should be concrete slabs supported by the rigid waffle foundation.

Commercial Building - The commercial building floors may consist of concrete slabs-on-grade atop materials that have been reconstructed as engineered fill. Otherwise, the commercial building should have structurally supported slabs.

The driveway, any sidewalks or patios, and garage floors may consist of conventional concrete slabs-on-grade on a compacted subgrade without replacement, though it should be expected that some post-construction shifting of such slabs may occur. We have provided guidelines to help reduce post-construction movements, however, it is nearly impossible to economically eliminate all shifting.

To help reduce cracking, we recommend slabs be a minimum of 4 inches thick and be nominally reinforced with #4 bars at 18 inches on center, each way. Slabs which are thinner or more lightly reinforced may experience undesirable cosmetic cracking. However, actual reinforcement and thickness should be determined by the structural engineer based upon anticipated usage and loading.

In large non-interior slabs (e.g. patios, garage, etc.), score joints should be placed at a maximum of 10 feet on center. In sidewalks, score joints should be placed at a maximum of 5 feet on center. All slabs should be separated from adjacent improvements (e.g. footings, porches, columns, etc.) with expansion joints. Interior floor slabs will experience shrinkage cracking. These cosmetic cracks may be sealed with epoxy or other measures specified by the architect.

All interior slabs (including garage slab) should be underlain by a minimum of 4 inches of clean ¾ inch crushed drain rock. The drain rock should be covered by a vapor barrier which conforms to ASTM E1745-97 (e.g. Stego Wrap or an approved equivalent). The architect or structural engineer should determine if sand is required over the vapor barrier.

Slabs which will be subject to light vehicular loads and through which moisture transmission is not a concern (e.g. driveway) should be underlain by at least 6 inches of compacted baserock, in lieu of any sand and gravel. Exterior landscaping flatwork (e.g. patios and sidewalks) may be placed directly on proof-rolled soil subgrade materials (e.g. no granular subgrade), however, they will be potentially subject to greater amounts of shifting and moisture transmission.

As stated previously, in pavement (concrete or asphalt) areas to receive vehicular traffic, all baserock materials should be compacted to at least 95 percent of their MDD. Also, the upper 6 inches of native soil subgrade beneath any pavements should be compacted to at least 95 percent of its MDD.

Commercial building floor slabs should be tied to the foundations to limit differential movements. Garage slabs on lots 1 through 3 should be free floating. Garage slabs on lots 4 through 6 may be structurally supported or left to free float.

Drainage

Due to the flat nature of the site, it will be important to provide good drainage improvements at the property.

Surface Drainage - Adjacent to any buildings, the ground surface should slope at least 5 percent away from the foundations within 5 feet of the perimeter. Impervious surfaces should have a minimum gradient of 2 percent away from the foundation.

Surface water should be directed away from all buildings into drainage swales, or into a surface drainage system (i.e. catch basins and a solid drain line). "Trapped" planting areas should not be created next to any buildings without providing means for drainage (i.e. area drains).

All new roof eaves should be lined with gutters. The downspouts may be connected to solid drain lines, or may discharge onto paved surfaces which drain away from the structure. The downspouts may be connected to the same drain line as any catch basins, but must not connect to any perforated pipe drainage system.

Footing Drain - Due to the potential for changes to surface drainage provisions, it will be required to install a perimeter footing drain to intercept water attempting to enter the crawlspace, or under the floor slabs.

The footing drain system should consist of a 12 inch wide gravel-filled trench, *dug at least 12 inches below the elevation of the adjacent crawlspace or slab subgrade*. The trench should be lined with a layer of filter fabric (Mirafi 140N or equivalent) to prevent migration of silts and clays into the gravel, but still permit the flow of water. Then 1 to 2 inches of drain rock (clean crushed rock or pea gravel) should be placed in the base of the lined trench. Next a perforated pipe (minimum 3 inch diameter) should be placed on top of the thin rock layer. The perforations in the pipe should be face down. The trench should then be backfilled with more rock to within 6 inches of finished grade. The filter fabric should be wrapped over the top of the rock. Above the filter fabric 6 inches of native soils should be used to cap the drain. If concrete slabs are to directly overlay the drain, then the gravel should continue to the base of the slab, without the 6 inch soil cap. This drain should not be connected to any surface drainage system.

If a floor slab is used for the commercial building, an under-slab drain system should be installed, consisting of a perforated collector pipes spread no more than 20 feet apart, embedded within the sub slab drain rock, to evacuate any water which gathers within the drain rock.

Drainage Discharge - The surface drain lines should discharge at least 15 feet away from the house, preferably at the street. The discharge location(s) may need to be protected by energy dissipaters to reduce the potential for erosion. Care should be taken not direct concentrated flows of water towards neighboring properties. This may require the use of multiple discharge points.

The footing drain lines should discharge independently from the surface drainage system. A sump pump may be required for the footing drain discharge system. The surface and subsurface drain systems should not be connected to one another.

Drainage Materials - Drain lines should consist of hard-walled pipes (e.g. SDR 35 or Schedule 40 PVC). In areas where vehicle loading is not a possibility, SDR 38 or HDPE pipes may be used. Corrugated, flexible pipes may not be used in any drain system installed at the property.

Surface drain lines (e.g. downspouts, area drains, etc.) should be laid with a minimum 2 percent gradient (¼ inch of fall per foot of pipe). Any subsurface drain systems (e.g. footing drains) should be laid with a minimum 1 percent gradient (1/8 inch of fall per foot of pipe).

Utility Lines

Unless they pass through the perimeter footing drain system, all utility trenches should be backfilled with compacted native clay-rich materials or a concrete plug within 5 feet of any buildings. This will help to prevent migration of surface water into trenches and then underneath the structures' perimeter. The rest of the trenches may be compacted with other native soils or clean imported fill. Only mechanical means of compaction of trench backfill will be allowed. Jetting of sands is not acceptable. Trench backfill should be compacted to at least 90 percent of its MDD. However, under pavements, concrete flatwork, and footings the upper 12 inches of trench backfill must be compacted to at least 95 percent of its MDD.

Pavement

The new driveway may consist of concrete, interlocking pavers, or asphaltic concrete over Caltrans Class II aggregate base (baserock). The asphalt should have a minimum thickness of 2½ inches. The baserock should have a minimum thickness of 6 inches. All of the baserock and the upper 6 inches of soil subgrade should attain a minimum compaction of 95 percent of its MDD. Any fill below this layer should attain a minimum of 90 percent relative compaction.

Plan Review and Construction Observations

The use of the recommendations contained within this report is contingent upon our being contracted to review the plans, and to observe geotechnically relevant aspects of the construction.

We should be provided with a full set of plans to review at the same time the plans are submitted to the building/planning department for review. A minimum of one working week should be provided for review of the plans.
At a minimum, our observations should include: compaction testing of fills and subgrades; footing excavations; slab and driveway subgrade preparation; installation of any drainage system (e.g. under-slab, footing, and surface), and final grading. A minimum of 48 hours notice should be provided for all construction observations.

LIMITATIONS

This report has been prepared for the exclusive use of the addressee, and their architects and engineers for aiding in the design and construction of the proposed development. It is the addressee's responsibility to provide this report to the appropriate design professionals, building officials, and contractors to ensure correct implementation of the recommendations.

The opinions, comments and conclusions presented in this report were based upon information derived from our field investigation and laboratory testing. Conditions between or beyond our borings may vary from those encountered. Such variations may result in changes to our recommendations and possibly variations in project costs. Should any additional information become available, or should there be changes in the proposed scope of work as outlined above, then we should be supplied with that information so as to make any necessary changes to our opinions and recommendations. Such changes may require additional investigation or analyses, and hence additional costs may be incurred.

Our work has been conducted in general conformance with the standard of care in the field of geotechnical engineering currently in practice in the San Francisco Bay Area for projects of this nature and magnitude. We make no other warranty either expressed or implied. By utilizing the design recommendations within this report, the addressee acknowledges and accepts the risks and limitations of development at the site, as outlined within the report.

Respectfully Submitted;
GeoForensics, Inc.

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Geotechnical
STATE OF CALIFORNIA

Bernard A. Atendido
Field Engineer

cc: 5 to addressee

LOG OF BORING

DEPTH (ft)	SAMPLE NUMBER	SAMPLE LOC.	BLOW COUNTS (12 inches)	MATERIAL DESCRIPTION	DRY DENSITY (pcf)	MOISTURE CONTENT (70)
	1-1	Mod. Cal	11	silty CLAY with sand and small gravels; dark green brown; moist; firm (CL)	101.3	21.9
				GRAVELS; cream and tan; dry (GP)		
5	1-2	Mod. Cal	23	fine sandy SILT; green brown and red brown; moist; stiff (ML)	100.0	21.2
				grades to		
10	1-3	Mod. Cal	11	silty CLAY with sand; mottled green brown, red brown, and greenish gray; slightly moist; firm (CL)	-	-
15	1-4	SPT	24	gravelly coarse SAND; green brown; slightly moist; medium dense (SM)	-	-
20						
25						
30						

Refusal on first attempt at 4 feet on ?gravels?
Moved east 3 feet

Bottom of Boring at 17.5 feet

Groundwater aty 14.5 feet
Rose to 13.5 feet after 2.5 hours

Logged by: BA
Job# 216003
Drilled on 1/8/16

B-24 Truck Mounted Drilling Rig
140 Pound Hammer
No Groundwater

Mod. Cal Sampler
SPT Sampler

GEOFORENSICS, INC.

561 Pilgrim Dr., Suite D, Foster City, CA 94404

Tel: (650) 349-3369 Fax: (650) 571-1878

Figure A1 - Log of Boring 1

LOG OF BORING

DEPTH (ft)	SAMPLE NUMBER	SAMPLE LOC.	BLOW COUNTS (12 inches)	MATERIAL DESCRIPTION	DRY DENSITY (pcf)	MOISTURE CONTENT (70)
				silty CLAY with gravels; dark brown; moist (CL)		
5	2-1	Mod. Cal Sampler	34	silty CLAY and SAND with gravels; brown and orange brown; dry to slightly moist; very stiff (CL) (broken up cream & tan concrete with wire mesh at 4.5 to 5.5 feet)	111.7	12.5
10	2-2	Mod. Cal Sampler	14	fine sandy SILT with clay; red brown and dark gray; slightly moist; stiff (ML)	-	-
15	2-3	Mod. Cal Sampler	11	SILT with pockets of sand, decomposed granite, and sandstone fragments; red brown and gray; moist; firm (ML)	-	-
				silty sandy CLAY grading to silty SAND with decomposed granite and some clay; greenish gray; moist; loose (SM)		
20	2-4	SPT Sampler	9	silty CLAY; greenish gray; moist; firm (CH)	-	27.8
25				**Bottom of Boring at 19.5 feet** **Groundwater aty 14.5 feet** **Rose to 13.5 feet after 1.5 hours**		
30						

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Figure A2 - Log of Boring 2

LOG OF BORING

DEPTH (ft)	SAMPLE NUMBER	SAMPLE LOC.	BLOW COUNTS (12 inches)	MATERIAL DESCRIPTION	DRY DENSITY (pcf)	MOISTURE CONTENT (70)
	3-1		20	silty sandy CLAY with sandstone fragments; dark brown turning to red brown; slightly moist; stiff (CL)	101.9	16.1
5						
	3-2		20	silty CLAY with sand and sadnstone fragments; dark green brown; slightly moist; stiff (CL)	100.3	20.5
10				silty SAND with decomposed granite; red brown; slightly moist stiff (CL)		
				grades to		
	3-3		14	silty sandy CLAY with decomposed granite; mottled green brown, red brown, and greensih gray; moist; stiff (CL)	92.7	27.5
15						
20				**Bottom of Boring at 15.5 feet**		
25				**Groundwater aty 10 feet** **Dropped to 11 feet after 1 hour**		
30						

Logged by: BA
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Figure A3 - Log of Boring 3

LOG OF BORING

DEPTH (ft)	SAMPLE NUMBER	SAMPLE LOC.	BLOW COUNTS (12 inches)	MATERIAL DESCRIPTION	DRY DENSITY (pcf)	MOISTURE CONTENT (70)
				silty CLAY with small gravels; dark brown; slightly moist (CL)		
5	4-1		15	silty CLAY; dark red brown and greenish gray; slightly moist; stiff (CL)	-	-
10	4-2		24	silty CLAY with small gravels, pockets of sand, and sandstone fragments; dark brown and green brown; moist; stiff (CL)	101.8	24.1
15	4-3		18	silty sandy CLAY with gravels and sandstone fragments; dark brown and green brown; moist; stiff (CL)	106.1	21.5
20						
25				**Bottom of Boring at 15.5 feet** **Groundwater aty 11.5 feet**		
30						

Logged by: BA
Job# 216003
Drilled on 1/8/16

B-24 Truck Mounted Drilling Rig
140 Pound Hammer
No Groundwater

Mod. Cal Sampler

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Figure A4 - Log of Boring 4

LOG OF BORING

DEPTH (ft)	SAMPLE NUMBER	SAMPLE LOC.	BLOW COUNTS (12 inches)	MATERIAL DESCRIPTION	DRY DENSITY (pcf)	MOISTURE CONTENT (70)
				silty CLAY with small gravels; dark brown; slightly moist (CL)		
5	4-1		15	silty CLAY; dark red brown and greenish gray; slightly moist; stiff (CL)	-	-
10	4-2		24	silty CLAY with small gravels, pockets of sand, and sandstone fragments; dark brown and green brown; moist; stiff (CL)	101.8	24.1
15	4-3		18	silty sandy CLAY with gravels and sandstone fragments; dark brown and green brown; moist; stiff (CL)	106.1	21.5
20						
25				**Bottom of Boring at 15.5 feet** **Groundwater aty 11.5 feet**		
30						

Logged by: BA
Job# 216003
Drilled on 1/8/16

B-24 Truck Mounted Drilling Rig
140 Pound Hammer
No Groundwater

Mod. Cal Sampler

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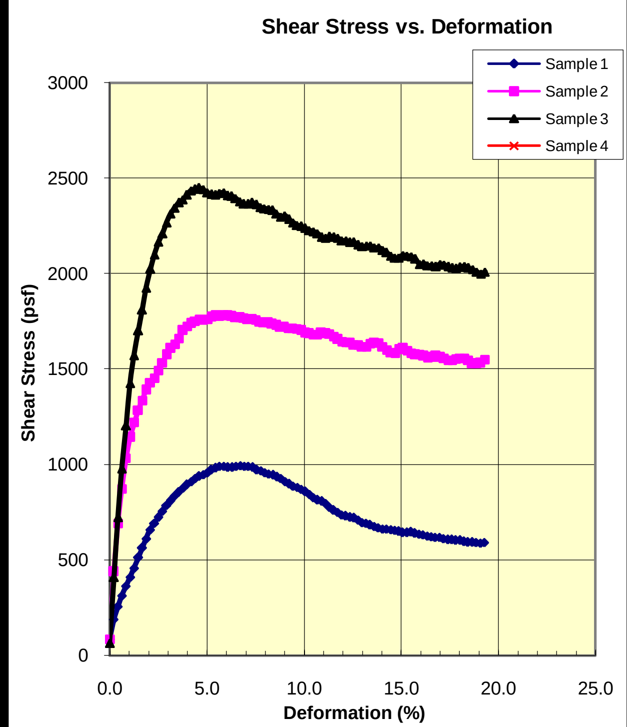
Figure A4 - Log of Boring 4

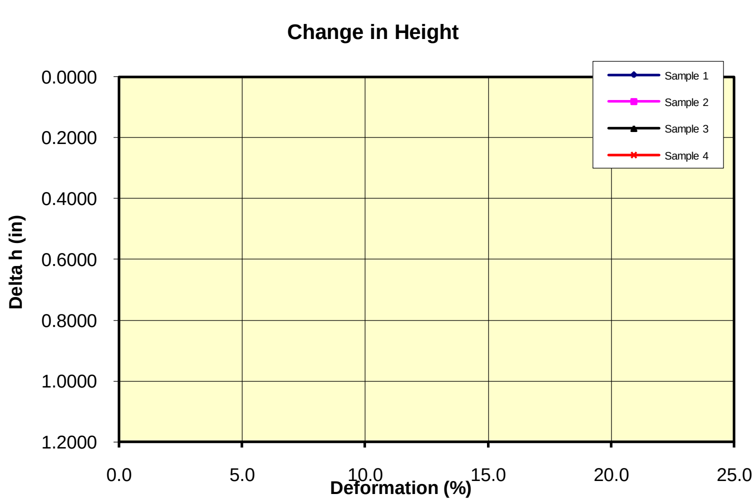
Consolidated Undrained Direct Shear(ASTM D3080M)

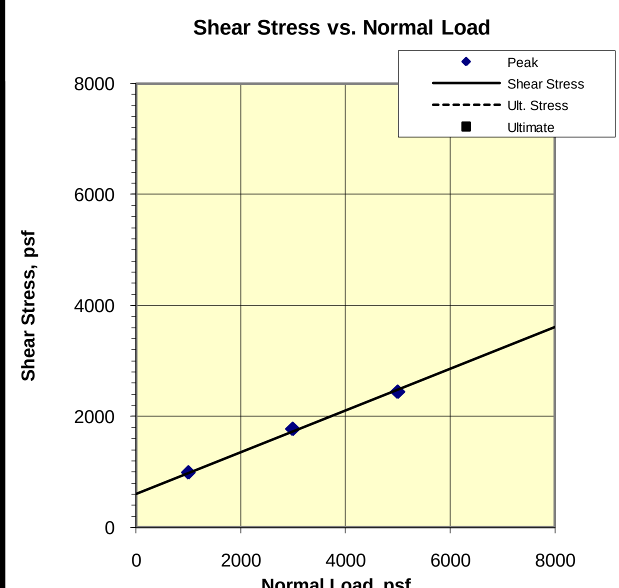
CTL Job #:	060-2392	Project #:	216003	By:	MD
Client:	GeoForensics	Date:	1/20/2016	Checked:	PJ
Project Name:	San Pedro	Remolding Info:			

Phi (deg)	20.6	Ult. Phi (deg)	
Cohesion (psf)	600	Ult. Cohesion (psf)	

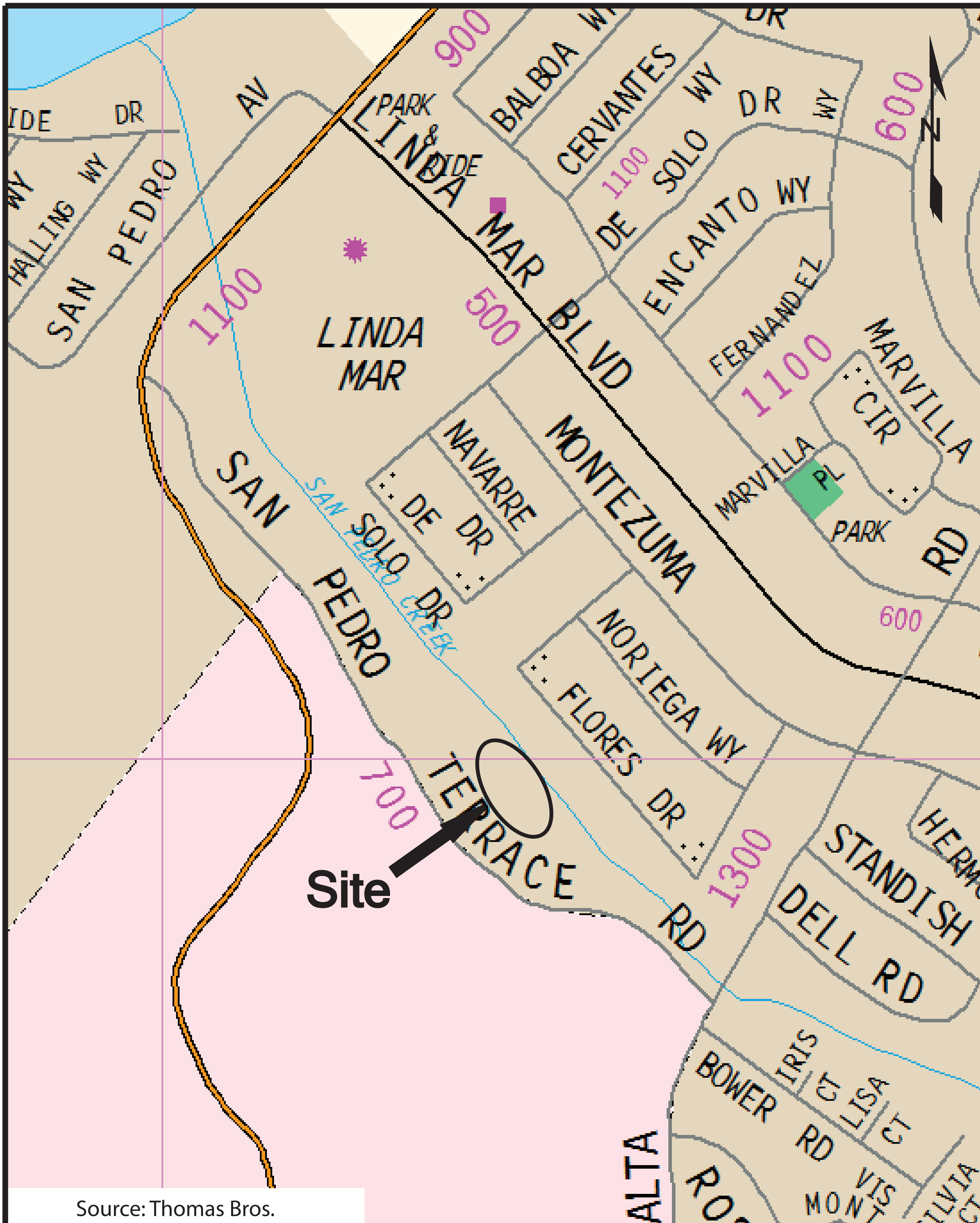
Specimen Data	1	2	3	4
Boring:	2-2	2-2	2-2	
Sample:				
Depth (ft):	9	9	9	
Visual Description:	Dark Brown Sandy CLAY	Dark Brown Sandy CLAY	Dark Brown Sandy CLAY	
Normal Load (psf)	1000	3000	5000	
Dry Mass of Specimen (g)	69.7	75.5	78.9	
Initial Height (in)	1.00	1.00	1.01	
Initial Diameter (in)	2.43	2.43	2.43	
Initial Void Ratio	2.054	1.818	1.710	
Initial Moisture (%)	59.1	56.3	54.2	
Initial Wet Density (pcf)	91.1	96.9	99.5	
Initial Dry Density (pcf)	57.2	62.0	64.5	
Initial Saturation (%)	80.6	86.7	88.8	
ΔHeight Consol (in)	0.0228	0.0886	0.1096	
At Test Void Ratio	1.984	1.569	1.414	
At Test Moisture (%)	64.0	55.6	50.4	
At Test Wet Density (pcf)	96.2	106.0	109.0	
At Test Dry Density (pcf)	58.6	68.1	72.5	
At Test Saturation (%)	90.4	99.3	99.8	
Strain Rate (%/min)	1.0	1.0	1.0	
Strengths Picked at	Peak	Peak	Peak	
Shear Stress (psf)	994	1779	2450	
ΔHeight (in) at Peak				
Ultimate Stress (psf)				







Remarks: *DS-CU* A fully undrained condition may not be attained in this test. ΔH is not measured during undrained direct shear tests.



Source: Thomas Bros.

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Figure 1 - Site Location

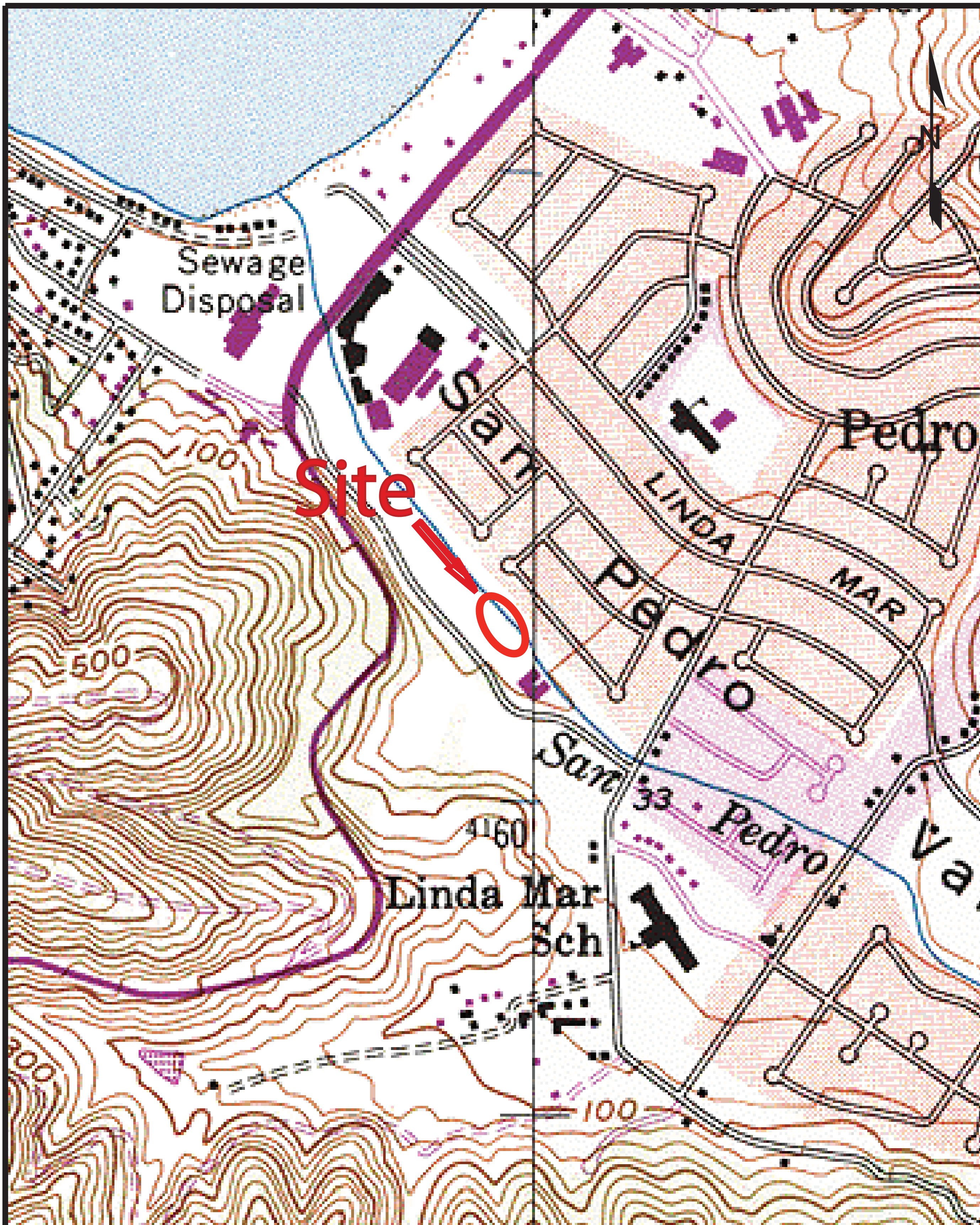

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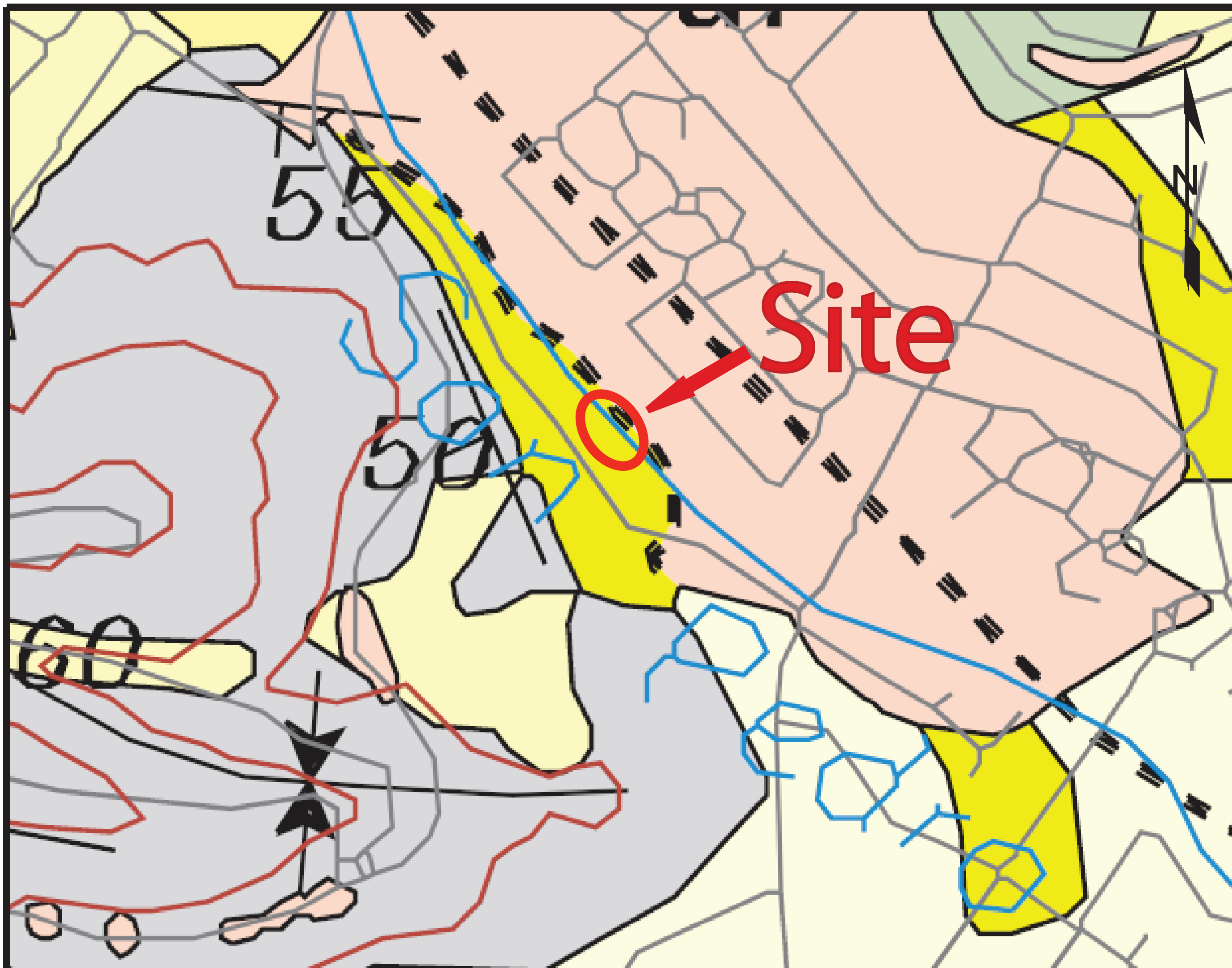
Figure 2 - Vicinity Topography



Artificial fill (Historic)—Loose to very well consolidated gravel, sand, silt, clay, rock fragments, organic matter, and man-made debris in various combinations. Thickness is variable and may exceed 30 m in places. Some is compacted and quite firm, but fill made before 1965 is nearly everywhere not compacted and consists simply of dumped materials

Younger (outer) alluvial fan deposits (Holocene)—Unconsolidated fine sand, silt, and clayey silt

Source: Geology of the Onshore part of San Mateo County, California: derived from the digital database open-file 98-137. E.E.. Brabb, R.W. Graymer, and D.L. Jones (1998)

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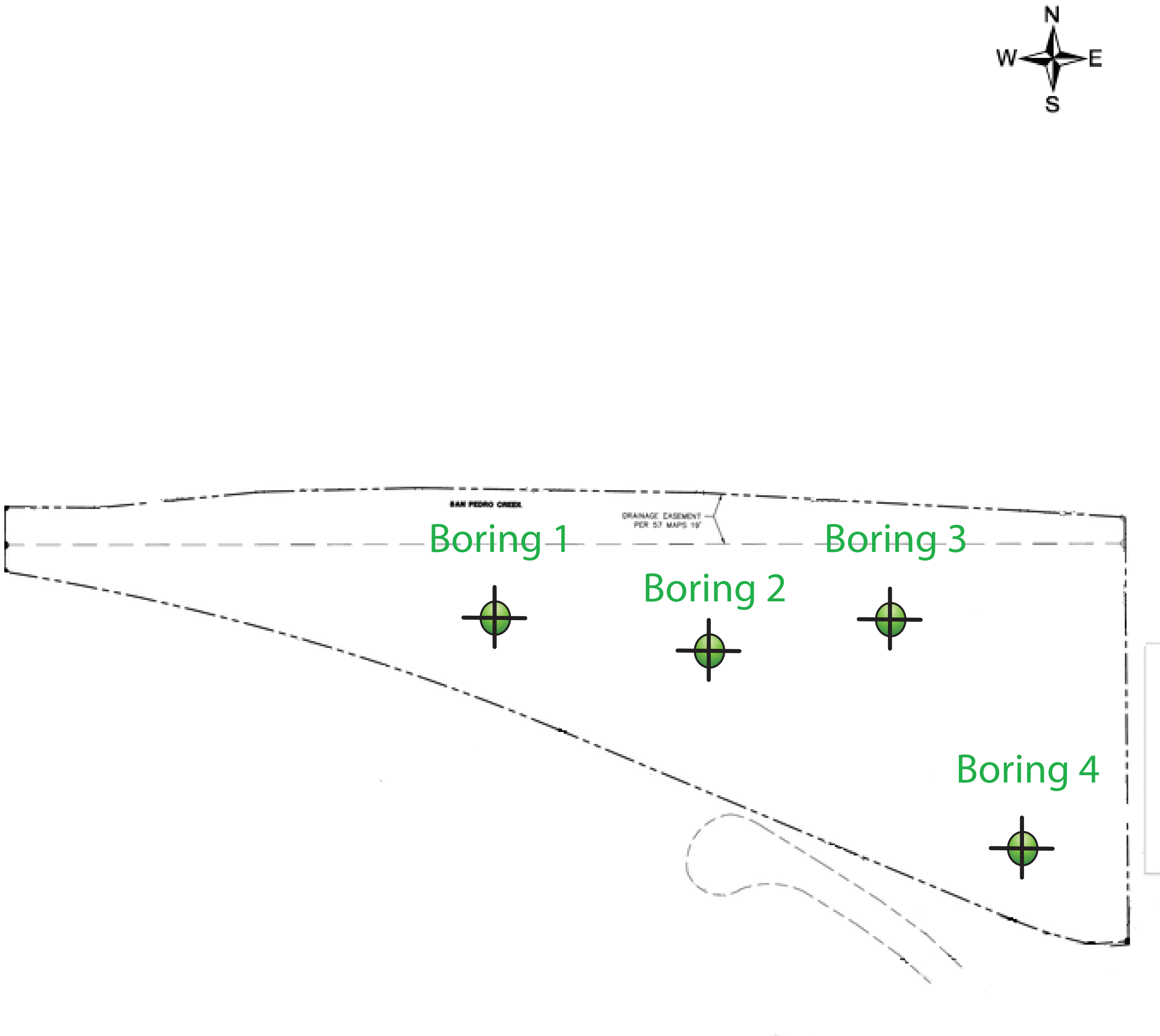
Figure 3 - Geologic Map



Base drawing provided by Structural Engineer
No Scale on this drawing

- Boring Locations

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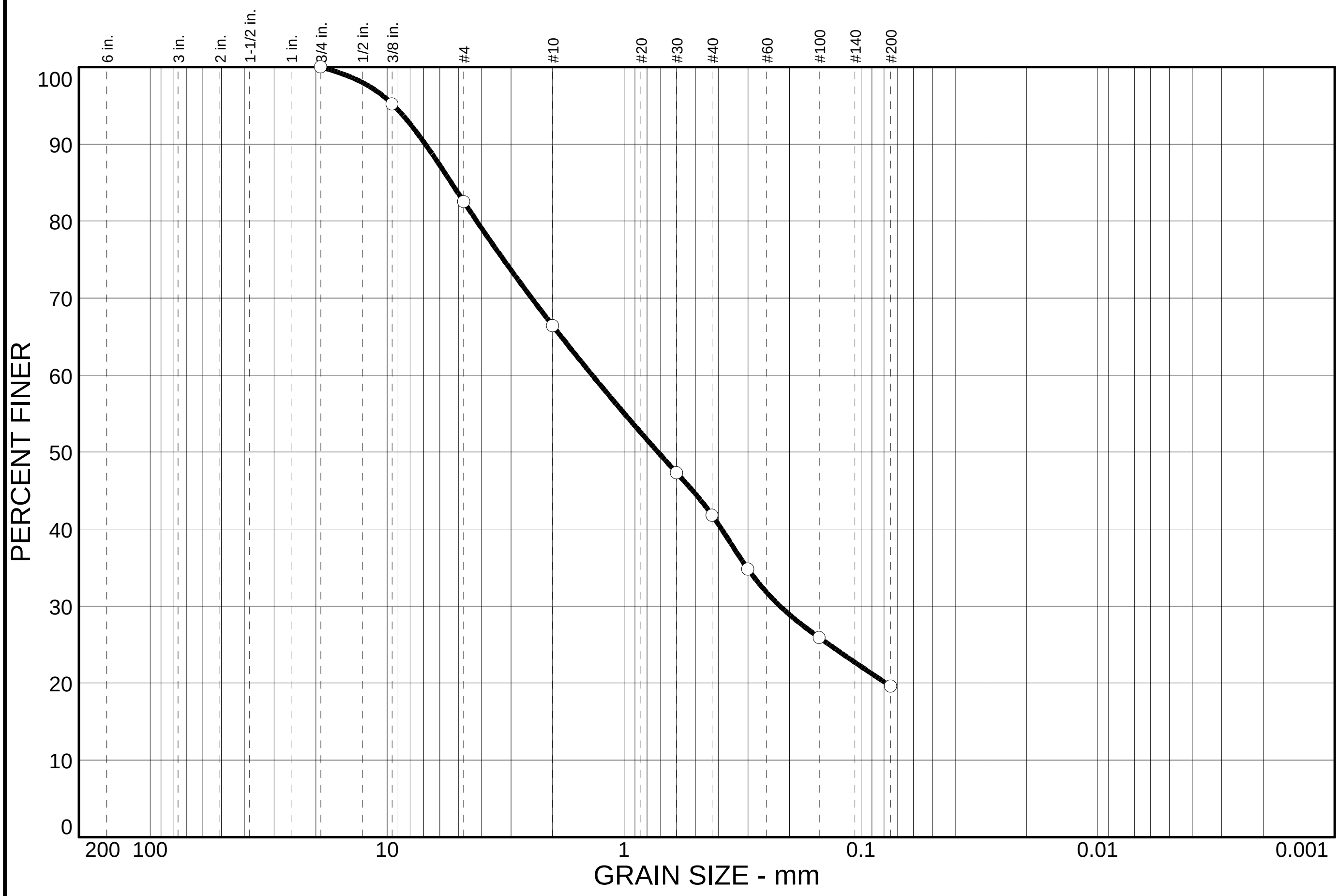
Figure 4 - Site Photo with Approximate Boring Locations

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		17.5	62.9	19.6					

SIEVE inches size	PERCENT FINER ○		
3/4"	100.0		
3/8"	95.2		
	GRAIN SIZE		
D_{60}	1.36		
D_{30}	0.220		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	82.5		
#10	66.4		
#30	47.3		
#40	41.8		
#50	34.8		
#100	25.9		
#200	19.6		

SOIL DESCRIPTION

○ Yellowish Brown Clayey SAND w/ Gravel

REMARKS:

○

○ Source: 1-4

Elev./Depth: 17'

COOPER TESTING LABORATORY

Client: GeoForensics

Project: San Pedro - 216003

Project No.: 060-2392

Figure

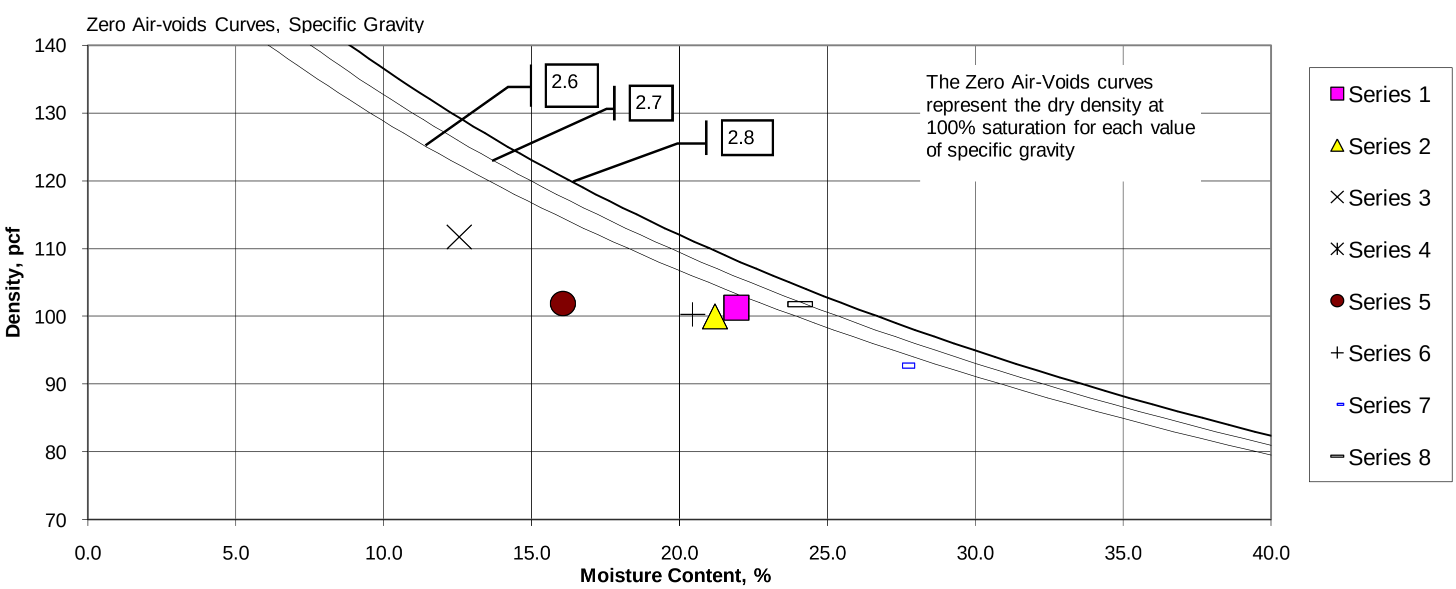
Moisture-Density-Porosity Report
Cooper Testing Labs, Inc. (ASTM D7263b)

CTL Job No: 060-2392a **Project No.** 216003 **By:** RU
Client: GeoForensics **Date:** 01/15/16
Project Name: San Pedro **Remarks:**

Boring:	1-1	1-2	2-1	2-4	3-1	3-2	3-3	4-2
Sample:								
Depth, ft:	2	7	4	19	3	8	13	10
Visual Description:	Very Dark Brown Sandy CLAY, trace organics	Dark Brown Sandy CLAY, trace Gravel	Dark Brown Sandy CLAY	Gray Sandy CLAY	Grayish Brown Sandy CLAY w/ Gravel (loose)	Dark Brown Sandy CLAY w/ Gravel	Olive Brown Sandy CLAY w/ Gravel	Gray Sandy CLAY w/ Gravel
Actual G_s								
Assumed G_s	2.70	2.70	2.70		2.70	2.70	2.70	2.70
Moisture, %	21.9	21.2	12.5	27.8	16.1	20.5	27.5	24.1
Wet Unit wt, pcf	123.5	121.2	125.8		118.3	120.8	118.2	126.3
Dry Unit wt, pcf	101.3	100.0	111.7		101.9	100.3	92.7	101.8
Dry Bulk Dens.ρb, (g/cc)	1.62	1.60	1.79		1.63	1.61	1.48	1.63
Saturation, %	88.9	83.4	66.5		66.2	81.0	90.7	98.9
Total Porosity, %	40.0	40.7	33.8		39.6	40.5	45.0	39.7
Volumetric Water Cont,Θw,%	35.5	34.0	22.4		26.2	32.8	40.9	39.2
Volumetric Air Cont., Θa,%	4.4	6.8	11.3		13.4	7.7	4.2	0.4
Void Ratio	0.67	0.69	0.51		0.65	0.68	0.82	0.66
Series	1	2	3	4	5	6	7	8

Note: All reported parameters are from the as-received sample condition unless otherwise noted. If an assumed specific gravity (Gs) was used then the saturation, porosities, and void ratio should be considered approximate.

Moisture-Density



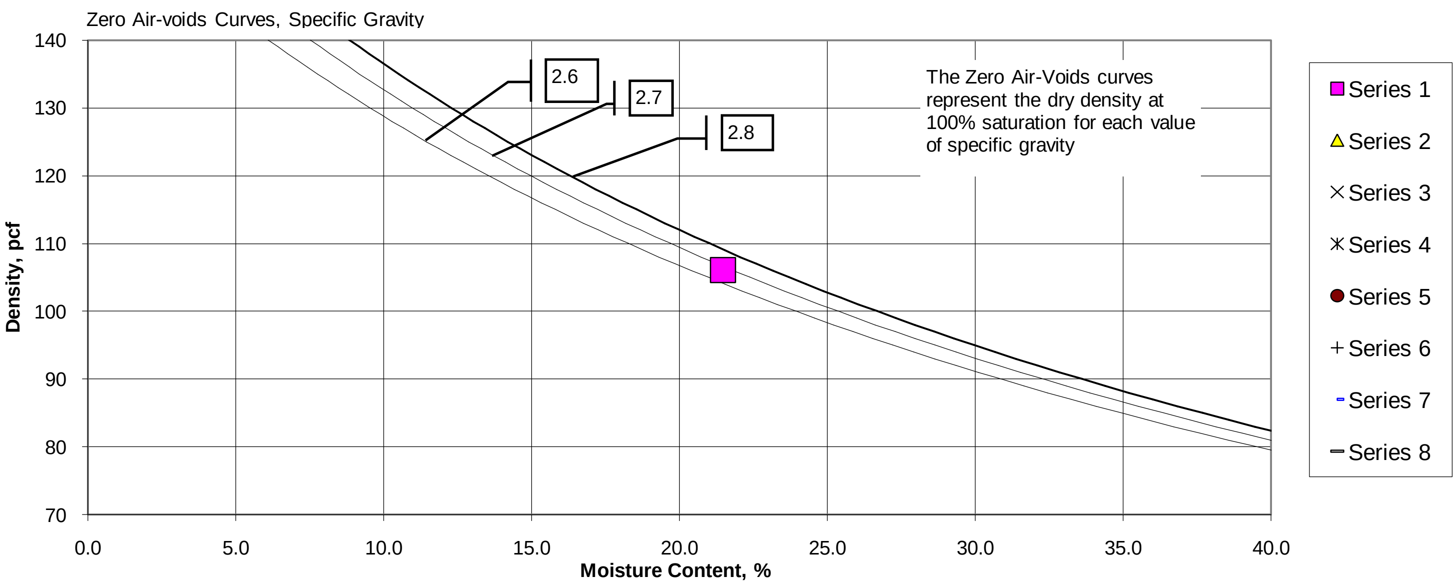
Moisture-Density-Porosity Report
Cooper Testing Labs, Inc. (ASTM D7263b)

CTL Job No:	060-2392b	**Project No.**	216003	**By:** RU
Client:	GeoForensics	**Date:**	01/15/16	
Project Name:	San Pedro	**Remarks:**		

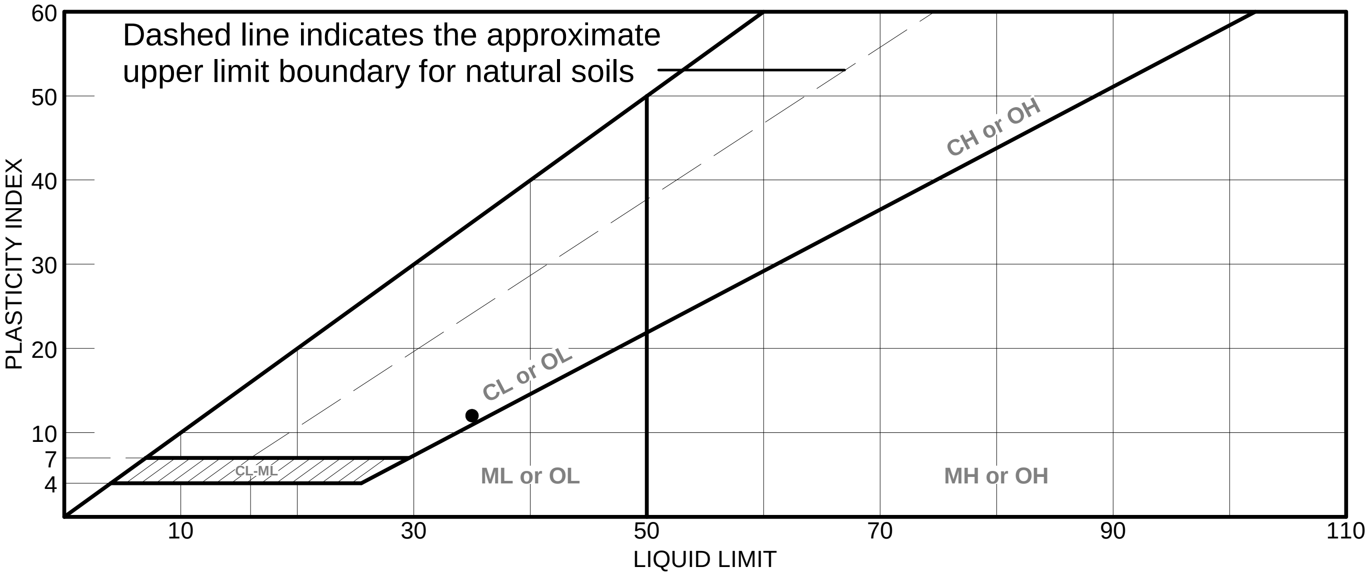
Boring:	4-3							
Sample:								
Depth, ft:	15							
Visual Description:	Dark Olive Brown Sandy CLAY, trace Gravel							
Actual G_s								
Assumed G_s	2.70							
Moisture, %	21.5							
Wet Unit wt, pcf	128.9							
Dry Unit wt, pcf	106.1							
Dry Bulk Dens.ρb, (g/cc)	1.70							
Saturation, %	98.2							
Total Porosity, %	37.1							
Volumetric Water Cont,Θw,%	36.4							
Volumetric Air Cont., Θa,%	0.7							
Void Ratio	0.59							
Series	1	2	3	4	5	6	7	8

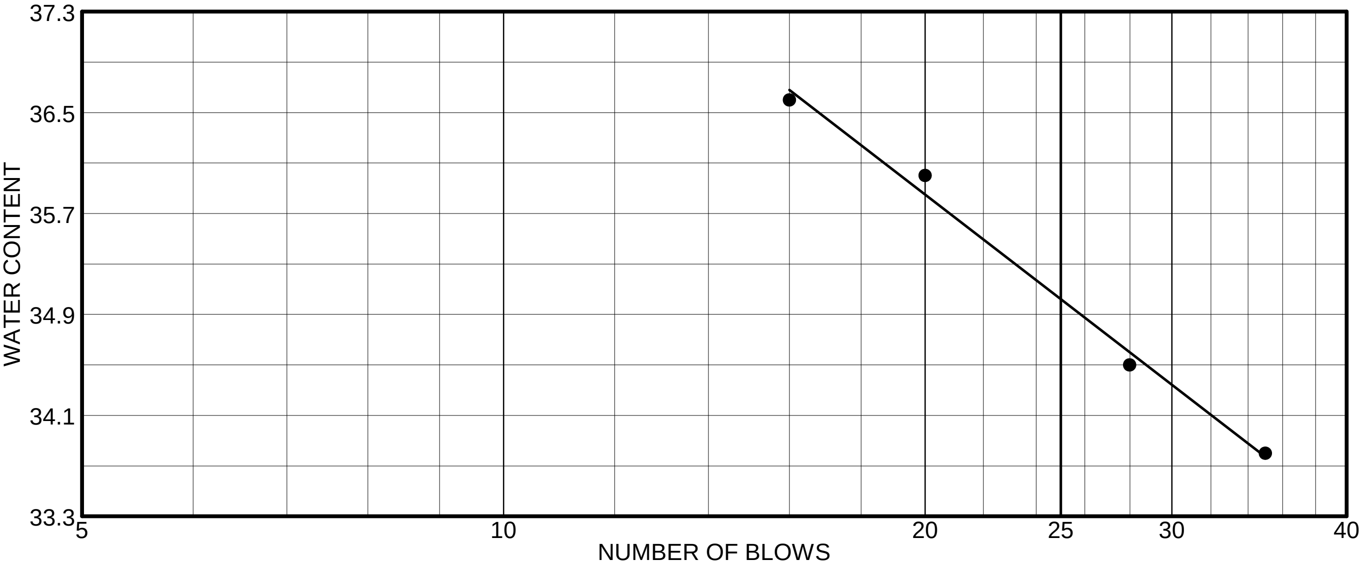
Note: All reported parameters are from the as-received sample condition unless otherwise noted. If an assumed specific gravity (Gs) was used then the saturation, porosities, and void ratio should be considered approximate.

Moisture-Density



LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Dark Grayish Brown Sandy Lean CLAY	35	23	12			

Project No. 060-2392 **Client:** GeoForensics

Project: San Pedro - 216003

● **Source:** 4-1 **Elev./Depth:** 5'

Remarks:

●

LIQUID AND PLASTIC LIMITS TEST REPORT

COOPER TESTING LABORATORY

Figure