APPENDIX D
GEOTECHNICAL INVESTIGATION

GEOTECHNICAL INVESTIGATION
FOR PROPOSED
NEW APARTMENT BUILDING

at the

Oak Grove Avenue Property

1491-1493 Oak Grove Avenue

Burlingame, California

Report Prepared for:

CHS Development

Report Prepared by:

GeoForensics, Inc.

July 2014

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File: 214097
July 29, 2014

CHS Development
Attention: Mr. Shao
1528 South El Camino Real, Suite 406
San Mateo, CA 94402

Subject: **Oak Grove Avenue Property**
1491-1493 Oak Grove Avenue
Burlingame, California
GEOTECHNICAL INVESTIGATION FOR PROPOSED NEW APARTMENT BUILDING

Dear Mr. Shao:

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 apartment building with a basement level garage.

Site Description

The subject site is two adjacent relatively level, rectangularly-shaped parcels located on the south side of Oak Grove Avenue (at the approximate location shown on Figure 1). For purposes of description in this report, it is assumed that the two lots face north. The property is bounded by other developed single family residential lots to the sides and rear, and Oak Grove Avenue to the north.

The site is currently occupied by two one-story, wood-framed residences situated near the centers of each lot. There are detached garages off the rear corners of the houses. The wooden house floors are supported above crawlspace areas, while the garages have concrete slab-on-grade floors. Concrete driveways lead from the street to the garages of both houses.

The ground surface in the site vicinity has an overall gentle slope down towards the east (as shown on Figure 2). At the site, the ground slopes gently down towards the east. Surface gradients range from level to 20:1 (horizontal:vertical, H:V). During the original development of the property, it appears that little or no grading work was required to create the existing level building pads.

The grounds around the residences have been landscaped with front and rear lawn areas, a variety of small to medium sized bushes and shrubs, and numerous small to large trees. Concrete walkways lead to the front entrance. Concrete walkways or planter areas are along the left sides of the houses. There are raised wood decks and concrete patios to the rear of the houses.

Proposed Construction

We understand that the current development for the site proposes the demolition of the existing residences, and the subsequent construction of a new apartment building with below grade parking. The apartment is to have a full basement level garage. The apartment is to be of conventional, wood-framed construction with concrete walls for the basement garage. New foundation loads are expected to be typical for this type of structure (i.e. light).

Excavation work at the site is expected to include: crawlspace, foundation, and basement excavations up to about 10 feet deep. No significant fill placement is anticipated as part of this work. Cuts up to 10 feet tall for the basement garage are anticipated as part of the site development. Garage retaining walls up to 10 feet tall will be required for the proposed construction.

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 apartment 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 - drilled three borings near the location of the proposed improvements;
4 - performed laboratory testing on collected soil samples;
5 - 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 July 24, 2014 to observe the geotechnically relevant site conditions. During our visit, we noted the following conditions:

A - The existing houses appear to be supported by perimeter concrete footings. The foundation system appeared to be good condition, with no major cracks (as observed from the exterior).

B - No cracks were observed in the concrete walkways.

C - We observed hairline to 1/16 inch wide cracks in the concrete driveways.

D - The exterior house walls were covered with stucco. The stucco walls were generally in good condition. Minor hairline to 1/16 inch wide cracks were observed at some openings in the walls.

E - We consider the drainage around the houses to be poor to fair. The roof downspouts discharge collected water onto concrete surfaces. However, the ground surface near the houses, and over much of the two lots, is flat without sufficient slope away from the houses to adequately carry water away from the houses. Water which is discharged, collected, or trapped by the house foundations may seep into the crawlspace.

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 indicates that the site is underlain by Alluvial Fan and Fluvial Deposits (Pleistocene) (map symbol "Qpaf"). Brabb, Graymer, and Jones describe these materials as consisting of "brown dense gravelly and clayey sand or clayey gravel that fines upward to sandy clay. These deposits display variable sorting and are located along most stream channels in the county. All Qpaf deposits can be related to modern stream courses. They are distinguished from younger alluvial fans and fluvial deposits by higher topographic position, greater degree of dissection, and stronger soil profile development. They are less permeable than Holocene deposits and locally contain fresh water mollusks and extinct late Pleistocene vertebrate fossils. They are overlain by Holocene deposits on lower parts of the alluvial plain, and incised by channels that are partly filled with Holocene alluvium on higher parts of the alluvial plains. Maximum thickness is unknown, but at least 50 m."

Our subsurface exploration (see below) encountered clay and sand materials which we judged to be consistent with the mapping.

The active San Andreas Fault is mapped approximately 2.3 miles (3.7 km) southwest of the site.

Subsurface Exploration

On July 24, 2014 we drilled three borings at the site at the locations shown on Figure 4. The borings were drilled using a Mobile B-24 truck-mounted drilling rig 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 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 have not been adjusted to reflect equivalent blows of any other type of sampler or hammer.

Subsurface Conditions

Boring 1 (in front of 1493 Oak Grove) first penetrated 3 feet of sandy silt. This was underlain by stiff to hard silty clay with varying amounts of gravel. This material graded to a medium dense silty sand by a depth of 32 feet. The boring was terminated in the sand at a depth of 33.5 feet.

Boring 2 (right rear of 1493 Oak Grove) and Boring 3 (in front of 1491 Oak Grove) penetrated 2 to 3 feet of fine sandy silt. Below the silt was stiff to hard silty clay with varying amounts of organics, sand, gravel, and chert fragments down to the terminated boring depths of 17.5 and 19 feet.

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

Initially, groundwater was encountered at depths of 23 feet (Boring 1) and 18.5 feet (Boring 2) 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 hours. In Boring 2, the level of the water rose to 14 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, and plasticity. The results of the laboratory tests are attached to this report in Appendix B.

Plasticity Index (PI) testing performed on the site near surface materials produced PI results of 32 and 42. This testing indicated that the near surface materials have moderate to high plasticity and are moderately to highly expansive.

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 expansive soils and groundwater just below the depth of the proposed basement elevation.

Expansive soils derive their name from their propensity to change volume in response to changes in moisture content. When they are dry, they shrink; when they become wet, they swell. The pressures these soils can exert as they expand can be sufficiently high to move conventional residential foundations. The foundation movement induced by the soil shifting can cause wall coverings to crack, doors and windows to stick, and floors to slope. Seasonal movements of expansive soils have caused such distress to countless houses in the Bay Area.

To combat seasonal expansive soil movements, it is necessary to utilize a foundation system which derives its support from the deeper, more stable soils. However, as a basement will extend below the entire structure, it will serve as a "deep" foundation. Where the structure is not above the basement, piers should be used.

The recommendations in this report should be incorporated into the design and construction of the proposed new apartment 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	$SM_S = 2.140$	$SM_1 = 1.525$	$SD_S = 1.427$	$SD_1 = 1.017$

Landsliding - 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. These conditions were demonstrated to be absent in the upper 33.5 feet of site materials. Although deeper soils may potentially exist which may be subject to liquefaction, it is our opinion that the dense clayey soils which comprise the upper layers at this site will effectively mitigate potential results of liquefaction. Therefore, it is our opinion the liquefaction is unlikely to affect the subject property.

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.

It would be reasonable to use soils from the basement excavation to raise portions of the site grades to improve drainage of the site.

The placement of fills at the site is expected to include: utility trench backfill, basement wall 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 level 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. If native expansive soils are used for fill at the site, then the soils should be placed at 3 to 5% over Optimum Moisture Content and be compacted to **between** 85 to 90 percent of their MDD. 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 90 percent of its MDD.

If fills in excess of 3 feet thick are to be placed, our office should be contacted for further recommendations.

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 13 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.

At-Grade Apartment Building Foundations

Due to the presence of highly and moderately expansive site soils, any portion of the building not over a basement will need to be supported by a pier and grade beam foundation system.

Piers should penetrate a minimum of 12 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, and be spaced no closer than 4 diameters, center to center.

Holes greater than 13 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 3 feet. Lateral support may be assumed to be developed along the length of the pier below 3 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 3 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).

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 other isolated floor supports must also be pier supported to resist expansive soil uplift, however, they do not need to be connected by grade beams.

In order to reduce any expansive soil uplift forces on the base of the grade beams, the beams should have either a uniform 2 inch void between their base and the soil, or should be constructed with a knife edge and triangular shaped void in a rectangular trench. The void can be created by the use of prefabricated cardboard void material (e.g. K-void, SureVoid, Carton-void), half a sonotube faced concave down, or other methods devised by the contractor and approved by our offices. *The use of Styrofoam is <u>not</u> acceptable for creating the void.*

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.

<u>Basement Foundations, Walls, and Floors</u>

Wall Forces - Any basement retaining walls should be designed to resist an active pressure of 45 pcf Equivalent Fluid Weight (EFW), for retained slopes flatter than 4:1 (horizontal:vertical). If it is desired to create steeper retained slopes to reduce the heights of the walls, then the active pressure will need to be increased. An active pressure of 60 pcf EFW should be utilized for retained slopes with an inclination of 2:1 (H:V). Where retained slopes are greater than 4:1, though less than 2:1, the designer should linearly interpolate between 45 and 60 pcf EFW.

If the walls are considered to be restrained, they should be designed for an additional uniform pressure of 8H psf, where H is the height of the wall in feet. We leave it to the design professional's judgment in determining whether a wall is restrained or not. It is our opinion that a supplemental seismic loading for a basement wall is not necessary. However, if desired, the designer may also apply a seismic force of 10H to the retaining wall in addition to the normal active pressures. The walls should also be designed to resist a point load applied at the midpoint of the wall, equal to ½ of the maximum applied surcharge (if any).

Foundation Parameters – Any basement retaining walls, and any wall or column supports at the basement level, may be supported by a mat slab, where the lateral forces are transferred across the slabs to the opposite retaining walls. It will be necessary that the slabs be able to resist buckling due to the applied forces from the walls. The slabs/footings should bear on competent native materials, as determined by our office in the field. Localized deepening of the subgrade/footings may be required if variable conditions are encountered during construction.

When the floor slab has been incorporated directly into the retaining wall foundation system, then isolated footings should not be used. However, it may be necessary to thicken the slab/footing at various locations to account for isolated loads. The amount of slab thickening, where required, should be determined by the structural engineer. A Modulus of Subgrade Reaction of 100 tci may be used for slab design.

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 the opposing retaining wall, or by friction between the base of the slab and the subgrade. A friction coefficient of 0.35 may be assumed.

Wall Drainage - The above values have been provided assuming that a back-of-wall drain system will be installed to prevent build-up of hydrostatic pressures. This drainage system may consist of a prefabricated drainage panel (i.e. Miradrain) or a gravel and filter fabric type system. The walls should be waterproofed to prevent the transmission of efflorescence through the walls. The waterproofing should be specified by the designer, though we recommend the use of Bituthene, Miradri, or other similar waterproofing membrane.

Either drainage system should be installed with a minimum 3 inch diameter perforated pipe incorporated into the subslab granular section. Ideally the base of the pipe should be placed atop 1 to 2 inches of gravel, with its top even with the elevation of the basement subgrade (i.e. under the gravel. Perforations should be placed face-down (at 5 and 7 o'clock).

If used, the gravel system should consist of a minimum 12 inch wide column of drain rock (¾ inch rock or 3/8 inch pea gravel) extending the full width of the wall. The rock should continue to within 6 inches of finished grade. Prior to backfilling with the drain rock, a layer of filter fabric (Mirafi 140N or approved equivalent) should be placed against all soil surfaces to separate the rock and soil. The filter fabric should wrap over the top of the gravel and then a 6 inch thick cap of native soils should be placed at the top of the drain. If concrete flatwork is to directly overlay the back-of-wall drain, then the drain rock should continue to the base of the concrete. Additionally, where the drain will be located within crawlspace area, the gravel should continue to the crawlspace ground surface without the soil cap.

If prefabricated drainage panels are used, these panels should dead-end into the subslab gravel for collection under the slab. *The tops of the panels should be sealed and secured in accordance with the manufacturer's specifications. The base of the drainage panels should extend down below the top of the filter fabric-wrapped drain rock.*

Floor - The basement floor should consist of a mat slab. The entire slab should be underlain by at least 6 inches of clean, crushed drain rock. The drain rock should be covered by a moisture barrier which conforms to ASTM E1745-97 (e.g. Stego Wrap or an approved equivalent). The moisture barrier should wrap up the edges of the mat slab to be overlapped by the basement wall waterproofing. Perforated collector pipes should be embedded within the drain rock to carry any water which gathers within the drain rock to the back-of-wall drain discharge location. Spacing between the pipes should not exceed 20 feet. The need for any sand over the top of the vapor barrier should be determined by the slab designer or architect.

Window Well and Access Well Drainage - Window Well and Access Well Drainage should be tight lined to the same sump pump used for under-slab and wall drainage. This sump should be located in the stairwell area for easy access, and may discharge into the area drain system. There should be a minimum 4 inch lip between the wells and the floor slab. A high water alarm should be provided in the sump. Consideration should be given to a backup generator. No downspouts should discharge into any window well or stairwell/depressed patio.

Slabs-on-Grade

The at-grade building floors should not consist of concrete slabs-on-grade. This is due to the expansive nature of the site soils which would cause deformations in a conventional slab-on-grade. However, the driveway, any sidewalks or patios, and garage floor may consist of conventional concrete slabs-on-grade, though it should be expected that some seasonal/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 5 inches thick and be nominally reinforced with #4 bars at 12 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 your architect.

It would be prudent (though not required) to underlay all slabs with at least 24 inches of non-expansive materials. This will help to reduce future expansive soil movements of the slabs. Slabs which are not underlain by this non-expansive material may undergo excessive seasonal shifting.

All interior slabs (including garage slab) should be underlain by 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 <u>and</u> 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 the sand and gravel. The 6 inches of granular subgrade may be included as part of the 24 inches of non-expansive materials. 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 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 90 percent of its MDD.

To reduce post-construction expansive soil movements (i.e. heave) of any slabs, care should be taken to keep the subgrade moist for an extended period of time prior to pouring the slabs. *Shrinkage cracks should not be allowed to develop in the soil beneath any proposed slabs.*

<u>Drainage</u>

Due to the flat nature of the site and the expansive nature of the site soils, 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 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. If splash blocks are preferred, then a perimeter footing drain system **must** be installed.

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. Where the basement garage wall is at the perimeter of the building, it will serve as a perimeter footing drain system.

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*. 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, but may tie to the basement subdrain system.

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 and any back-of-wall 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, except as discussed above for the basement light and stairwells. The under-slab drainage system must discharge independently of any other drainage system, and must outlet at a location where any backup of a surface drainage system cannot backflow into the perforated portions of the subslab system.

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 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, though 12 inches is preferable due to the expansive nature of the near-surface site soils. All of the baserock 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; basement excavation; footing excavations; pier drilling; forming of the grade beams voids; slab and driveway subgrade preparation; installation of any drainage system (e.g. back-of-wall, 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.

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July 29, 2014

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.

Daniel F. Dyckman, PE, GE
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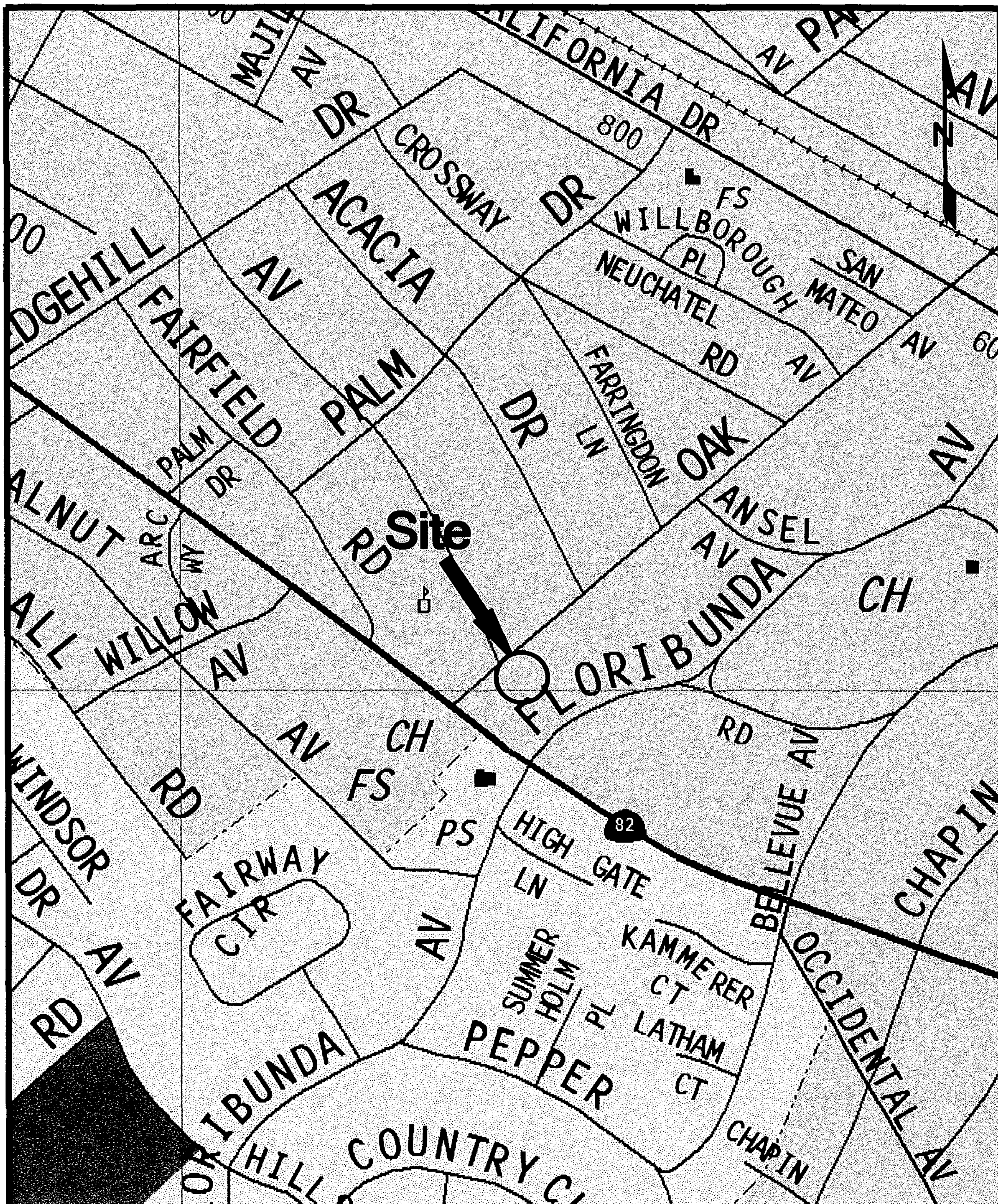

Source: Thomas Bros.

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Figure 1 - Site Location

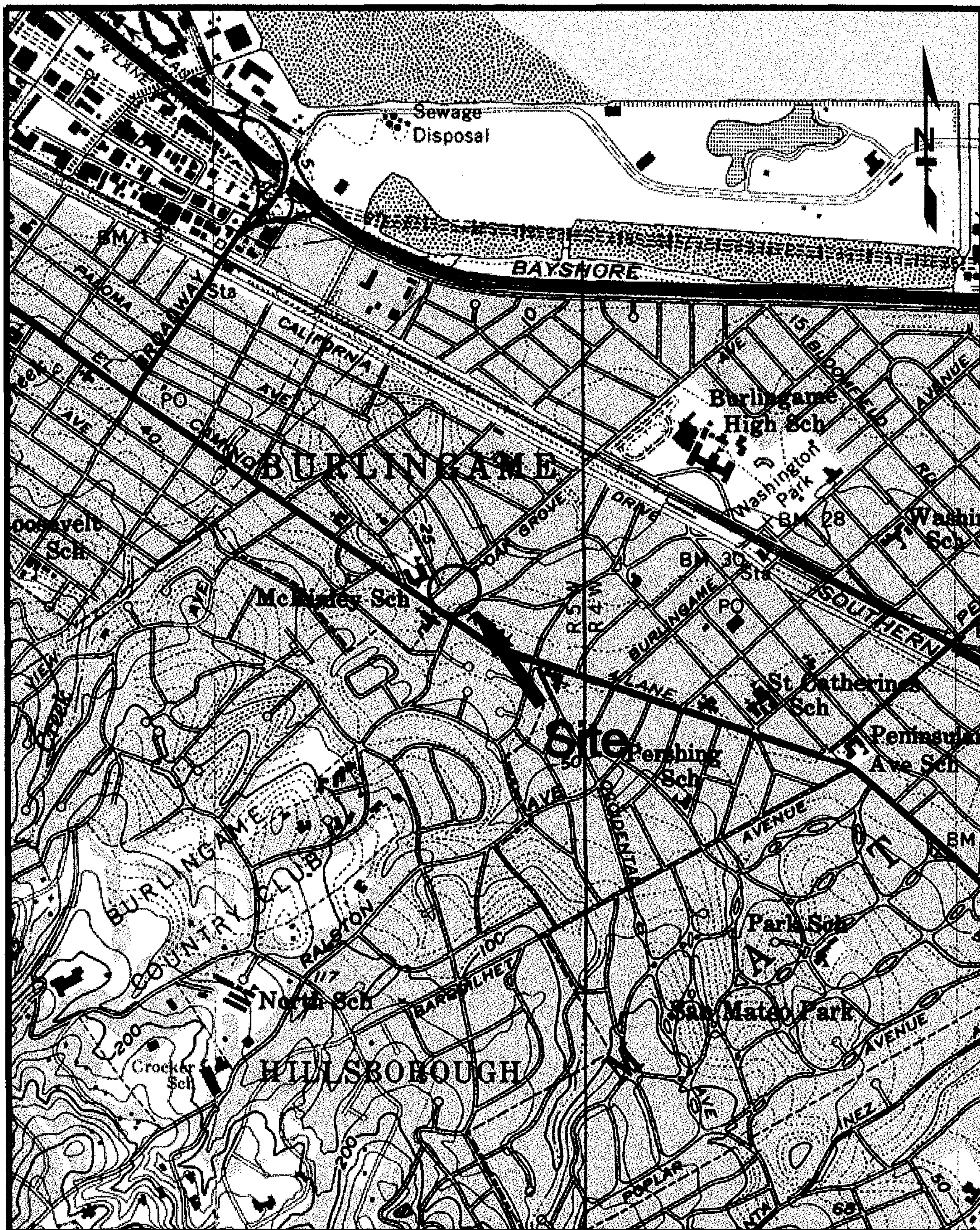

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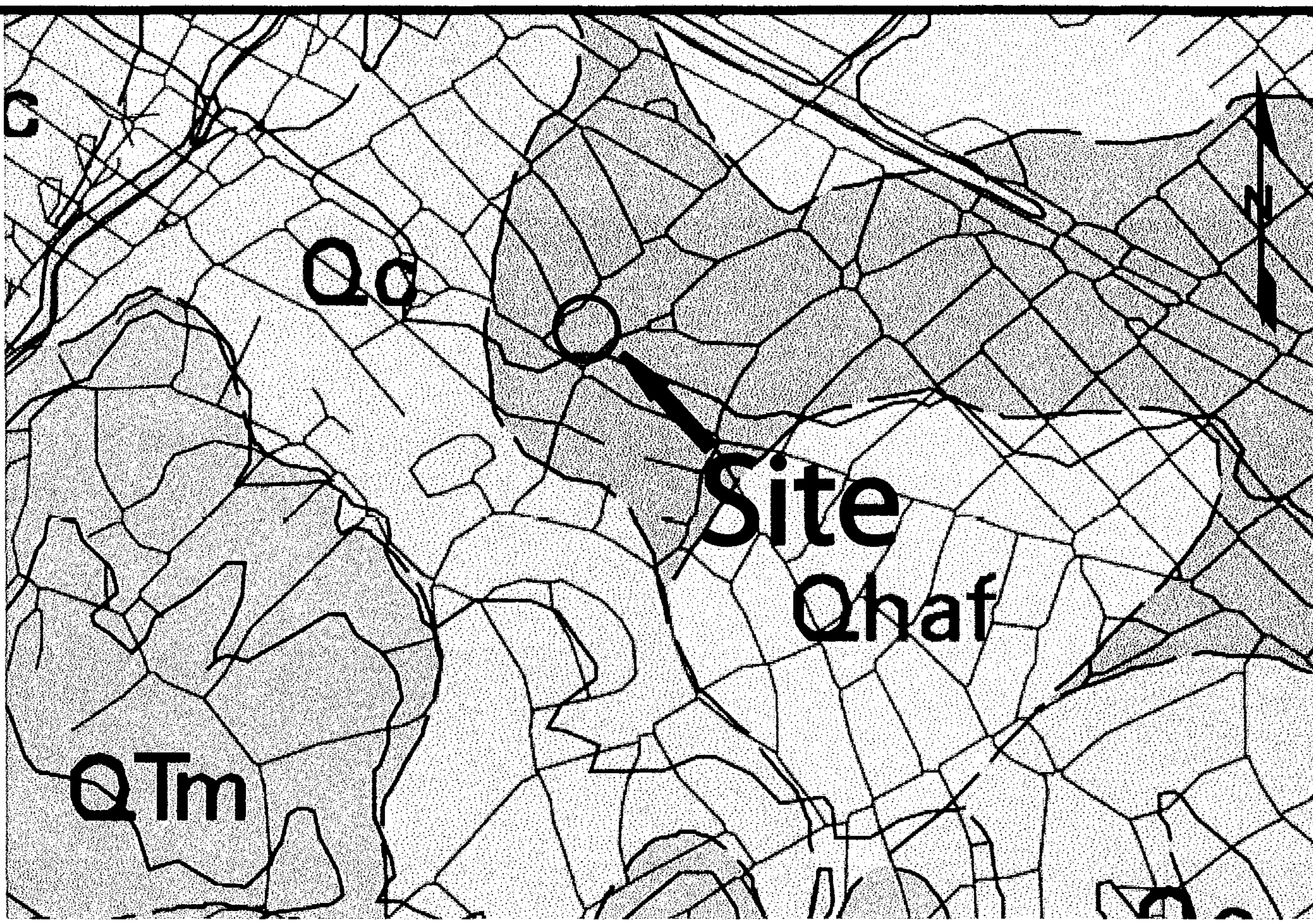
Figure 2 - Site Topography



Qpaf

Alluvial fan and fluvial deposits (Pleistocene) —Brown dense gravely and clayey sand or clayey gravel that fines upward to sandy clay. These deposits display variable sorting and are located along most stream channels in the county. All Qpaf deposits can be related to modern stream courses. They are distinguished from younger alluvial fans and fluvial deposits by higher topographic position, greater degree of dissection, and stronger soil profile development. They are less permeable than Holocene deposits, and locally contain fresh water mollusks and extinct late Pleistocene vertebrate fossils. They are overlain by Holocene deposits on lower parts of the alluvial plain, and incised by channels that are partly filled with Holocene alluvium on higher parts of the alluvial plain. Maximum thickness is unknown but at least 50 m.

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 Google Maps
No Scale on this drawing

- Boring Locations

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Figure 4 - Site Photo with Approximate Boring Locations

APPENDIX A - BORING LOGS

LOG OF BORING

DEPTH (ft)	SAMPLE NUMBER	SAMPLE LOC.	BLOW COUNTS (12 inches)	MATERIAL DESCRIPTION	DRY DENSITY (pcf)	MOISTURE CONTENT (70)
				Fine sandy SILT; brown; slightly moist (ML)		
				Silty CLAY with some sand; green brown; slightly moist (CH)		
5	1-1		85/10"	Silty CLAY (near clayey SILT) with trace fine sand; red brown and green brown; slightly moist; hard (CH)	110.5	19.3
10						
15	1-2		14	Silty CLAY; greenish gray and orange brown; slightly moist to moist; stiff (CH)	-	-
20						
25	1-3		30	Silty CLAY with small to large subrounded to rounded gravels; red brown and olive brown; slightly moist; very stiff (CH)	107.9	20.9
30				grades to		

Logged by: BA
Job# 214097
Drilled on 6/28/14

B-24 Truck Mounted Drilling Rig
140 Pound Hammer
Groundwater at 23 feet

Mod. Cal Sampler

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Figure A1 - Log of Boring 1
(page 1 of 2)

LOG OF BORING

DEPTH (ft)	SAMPLE NUMBER	SAMPLE LOC.	BLOW COUNTS (12 inches)	MATERIAL DESCRIPTION	DRY DENSITY (pcf)	MOISTURE CONTENT (70)
	1-4		42	Silty SAND; orange brown and tan; slightly moist; medium dense (SM)	116.0	16.3
35						
40						
45						
50						
55						
60						

Bottom of Boring at 33.5 feet

Groundwater at 23 feet
Rose to 13.5 feet after 2 hours

Logged by: BA
Job# 214097
Drilled on 6/24/14

B-24 Truck Mounted Drilling Rig
140 Pound Hammer
Groundwater at 23 feet

Mod. Cal Sampler

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Figure A1 - Log of Boring 1 (continued)

LOG OF BORING

DEPTH (ft)	SAMPLE NUMBER	SAMPLE LOC.	BLOW COUNTS (12 inches)	MATERIAL DESCRIPTION	DRY DENSITY (pcf)	MOISTURE CONTENT (70)
				6 inches of concrete over fine sandy SILT; brown; slightly moist (ML)		
5	2-1	◢	19	Silty CLAY with sand and some small gravels; red brown and green brown; slightly moist; stiff (CH)	-	-
10	2-2	◢	67	Silty CLAY with sand; red brown and green brown; slightly moist; hard (CH)	108.9	20.0
15	2-3	◢	26	Silty CLAY; greenish gray; slightly moist to moist; very stiff (CH)	96.6	26.8
	2-4	◢	26	Silty CLAY/clayey SILT; red brown and olive brown; slightly moist; very stiff (CH/MH)	97.0	27.4
20						
25				**Bottom of Boring at 18.5 feet** **Groundwater at 18.5 feet** **Rose to 14 feet after 1 hour**		
30						

Logged by: BA
Job# 214097
Drilled on 6/24/14

B-24 Truck Mounted Drilling Rig
140 Pound Hammer
Groundwater at 18.5 feet

Mod. Cal Sampler ◢

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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 (%)
				fine sandy SILT; brown; slightly moist (ML)		
	3-1		14	Silty CLAY with sand and chert fragments; red brown and green brown; slightly moist; stiff (CH)	101.0	6.4
5						
	3-2		57	Silty CLAY with organics, pockets of sand, and small rounded gravels; green brown; slightly moist; hard (CH)	106.1	21.6
10						
	3-3		29	Silty CLAY; greenish gray; slightly moist to moist; very stiff (CH)	112.4	18.1
15						
	3-4		19	Silty CLAY; red brown and olive brown; slightly moist; stiff (CH)	107.5	20.2
20				**Bottom of Boring at 17.5 feet**		
				No Groundwater Encountered		
25						
30						

Logged by: BA
Job# 214097
Drilled on 6/24/14

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

Mod. Cal Sampler

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Figure A3 - Log of Boring 3

APPENDIX B - LABORATORY TEST RESULTS

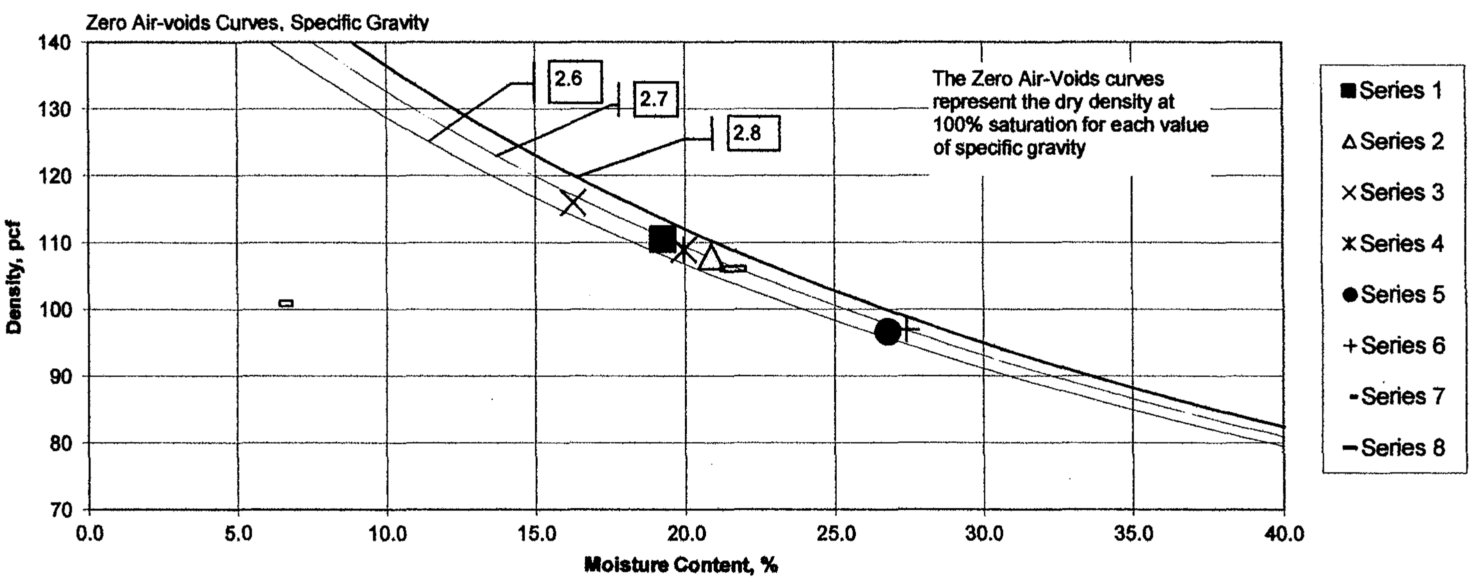
Moisture-Density-Porosity Report
Cooper Testing Labs, Inc. (ASTM D 2937)

CTL Job No: 060-2270a	**Project No.** 214097	**By:** RU
Client: GeoForensics	**Date:** 07/08/14	
Project Name: Oak Grove	**Remarks:**	

Boring:	1-1	1-3	1-4	2-2	2-3	2-4	3-1	3-2
Sample:								
Depth, ft:	6	24	33	8.5	13.5	18.5	2	7
Visual Description:	Olive Brown Sandy CLAY	Olive Brown Sandy CLAY	Olive Brown Sandy CLAY	Olive Brown CLAY w/ Sand & Roots	Pale Olive CLAY w/ Sand	Pale Olive CLAY w/ Sand	Olive Brown Sandy SILT w/ Gravel & organics (slightly plastic)	Light Olive Brown Sandy CLAY
Actual G_s								
Assumed G_s	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70
Moisture, %	19.3	20.9	16.3	20.0	26.8	27.4	6.4	21.6
Wet Unit wt, pcf	131.8	130.4	134.9	130.6	122.5	123.5	107.5	129.0
Dry Unit wt, pcf	110.5	107.9	116.0	108.9	96.6	97.0	101.0	106.1
Dry Bulk Dens.ρb, (g/cc)	1.77	1.73	1.86	1.74	1.55	1.55	1.62	1.70
Saturation, %	98.8	100.0	96.7	98.2	96.9	100.0	25.8	98.9
Total Porosity, %	34.5	36.0	31.2	35.4	42.7	42.5	40.1	37.1
Volumetric Water Cont,Θw,%	34.1	36.0	30.2	34.8	41.4	42.5	10.4	36.7
Volumetric Air Cont., Θa,%	0.4	0.0	1.0	0.6	1.3	0.0	29.8	0.4
Void Ratio	0.53	0.56	0.45	0.55	0.75	0.74	0.67	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

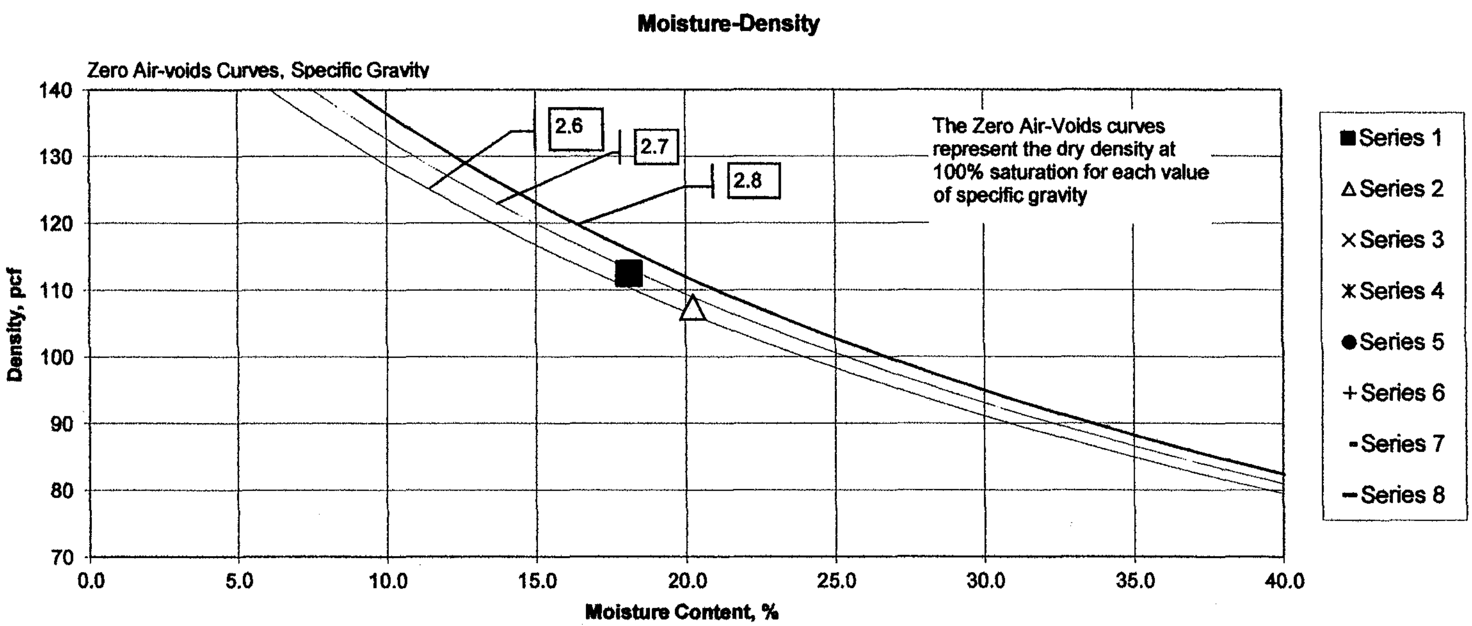


Moisture-Density-Porosity Report
Cooper Testing Labs, Inc. (ASTM D 2937)

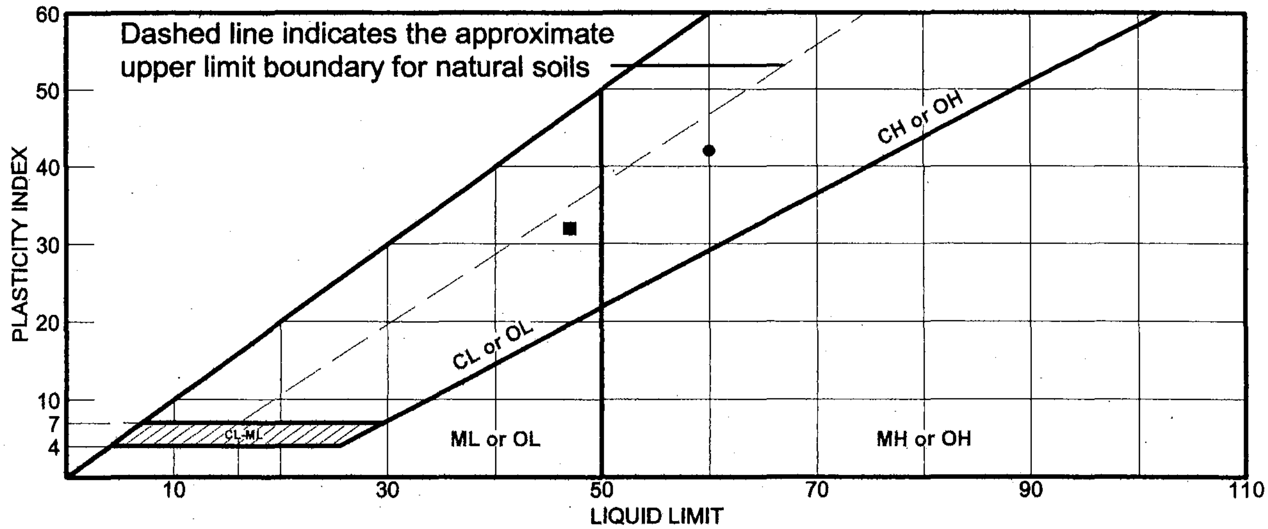
CTL Job No:	060-2270b	Project No.	214097	By:	RU
Client:	GeoForensics	Date:	07/08/14		
Project Name:	Oak Grove	Remarks:			

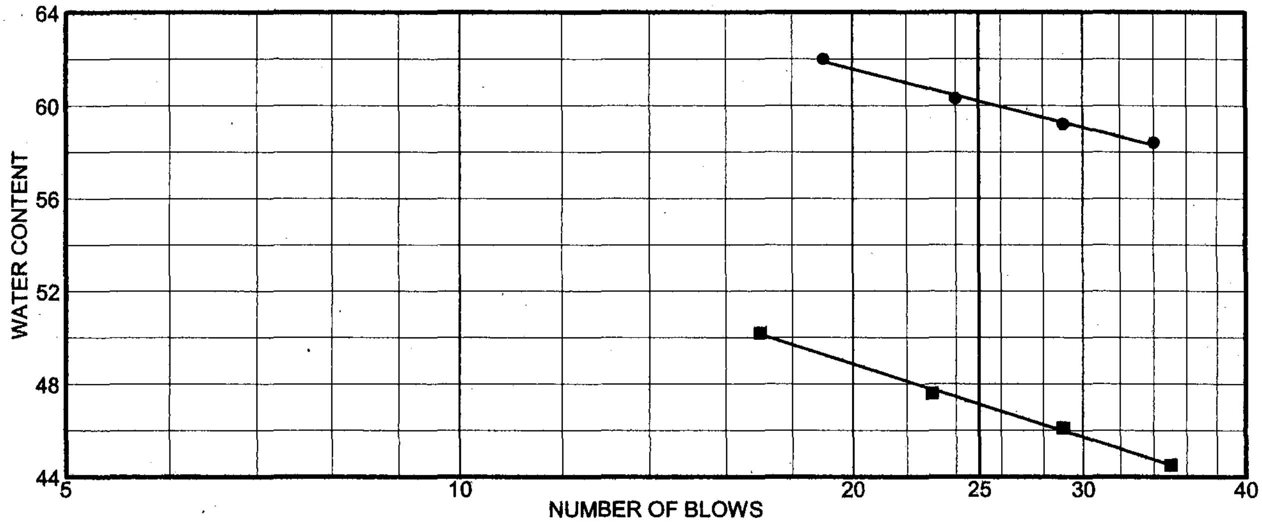
Boring:	3-3	3-4						
Sample:								
Depth, ft:	12	17						
Visual Description:	Olive Brown Sandy CLAY	Olive Brown Sandy CLAY						
Actual G_s								
Assumed G_s	2.70	2.70						
Moisture, %	18.1	20.2						
Wet Unit wt, pcf	132.8	129.2						
Dry Unit wt, pcf	112.4	107.5						
Dry Bulk Dens.pb, (g/cc)	1.80	1.72						
Saturation, %	97.7	95.9						
Total Porosity, %	33.3	36.3						
Volumetric Water Cont,Θw,%	32.6	34.8						
Volumetric Air Cont., Θa,%	0.8	1.5						
Void Ratio	0.50	0.57						
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.



LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Light Olive Brown Sandy Fat CLAY	60	18	42			
■	Dark Olive Brown Sandy Lean CLAY	47	15	32			

Project No. 060-2270 **Client:** GeoForensics

Project: Oak Grove - 214097

● **Source:** 1-2 **Elev./Depth:** 15'

■ **Source:** 2-1 **Elev./Depth:** 3.5'

Remarks:

●

■

LIQUID AND PLASTIC LIMITS TEST REPORT

COOPER TESTING LABORATORY

Figure