## City of Pittsburg
## Water Treatment Plant
## Capital Improvements Project

# Geotechnical Engineering Investigation Report

June 13, 2013

Prepared for:

Brown AND Caldwell

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June 13, 2013

Mr. Erik Zalkin
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**Subject:** Geotechnical Engineering Investigation Report

**Re:** Water Treatment Plant Capital Improvements Project
City of Pittsburg, California

Dear Mr. Zalkin:

We are pleased to submit the attached Geotechnical Engineering Investigation Report for the City of Pittsburg's Water Treatment Plant Capital Improvements Project in Pittsburg, California. This report follows and incorporates Brown and Caldwell reviews of our earlier draft report dated May 18, 2013 and email comments dated June 3, 2013.

We appreciate the opportunity to serve Brown and Caldwell on this interesting and important project. Please contact us if you have any questions regarding this report.

Sincerely,

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# 1 Introduction

## 1.1 Project Description

This geotechnical engineering investigation report is for the City of Pittsburg's (City) WTP Capital Improvements Project (Project) The Project includes the following new and future treatment plant processes:

- Chlorine Contact and Mixing Tank (new)
- Sludge Thickener Tank (new)
- MCC Building (new)
- Settled Sludge Thickener Pump Station (new)
- Thickened Sludge Pump Station (new)
- Forcemain from Thickener to Upper Pond (new)
- Upper Pond Partition Wall (new)
- Dewatering Building (future)
- Package Plate Settlers and Sludge Pumps (future)
- Recycle Equalization Basins (future)
- Dewatering Tank (future)

References to the project elements provided herein are based site map provided by Brown and Caldwell (2013). A project area map is provided on Figure 1. A map of project test boring and reference test boring locations is provided on Figure 2.

With the exception of the new upper pond partition wall, this report includes boring logs and laboratory testing for both new and future improvements and provides conclusions and recommendations for design, construction, and useful long-term performance for the new structures shown on Figure 2.

The geotechnical engineering field investigation for the new Upper Pond Partition Wall will be conducted after sludge within the Upper Pond is removed to allow drilling access into the Upper Pond. The subsurface investigation findings, conclusions, and recommendations for the Upper Pond PartitionWall will be issued as an addendum to the Project Geotechnical Report.

The findings, conclusions, and recommendations for design, construction, and usefull long-term performance of the future improvements will be provided when more information is availabe (e.g., location, size, depth, etc.).

# 2 Geotechnical Field Investigation and Laboratory Testing

## 2.1 Project Test Borings

Ten project test borings (Borings B-1through and Boring B-10) were drilled and logged on March 13 and March 14, 2013, using a truck-mounted Mobile B-24 drill rig equipped with a 5-inch-diameter continuous flight solid-stem auger (see Figure 2 for project boring locations).

For project test borings, relatively undisturbed soil samples were obtained by driving a 2.5-inch ID, 3.0-inch outside diameter (OD), Modified California Sampler (MCS) containing brass liners, into the bottom of the boring at the depths indicated on the logs. Disturbed soil samples were obtained by driving a 1.4-inch ID, 2.0-inch OD Standard Penetration Test (SPT) sampler into the bottom of the boring per American Society for Testing and Materials (ASTM) D1586 standards. A 140-pound hammer falling 30 inches per blow was used to drive MCS and SPT samplers. The number of blows required to drive the samplers the last 12 inches of an 18-inch drive is recorded on the boring logs as penetration resistance (blows/ft). The penetration resistance values (blows/ft) recorded for SPT sampler drives on the boring logs are actual (ASTM) D1586 N-values. The penetration resistance values recorded on boring logs for all MCS sampler drives are field blow counts for the respective sampler used and are not SPT N-values. Equivalent SPT N-values for the MCS sampler will be lower.

Soil samples retrieved from the project test borings were examined for classification, logged, and sealed to preserve their natural moisture content. Classification systems used to log the project test borings are provided in Appendix A. Descriptions of soils provided on the project test boring logs are based on observations during drilling and sampling and on the results of laboratory tests.

## 2.2 Project Test Borings and Reference Borings

Logs of test borings performed at Project site, described in Section 2.1, are provided in Appendix B. In addition to the project test borings, reference test borings were performed for former WTP projects. A map showing the location of the project test borings and reference borings is shown in Figure 2. Selected subsurface data from Borings B-1 through B-10 and Reference Borings RB-1 through RB-14 is presented in Table 1 and Table 2, below.

**Table 1. Partial Summary of Project Boring Data**

| Project Test Boring[1] | Drill Date (m-d-y) | Location[2] | Approx. Ground Surface El.[2] (ft) | Boring Depth (ft) | Groundwater Depth During Drilling (ft) [Elevation] |
|---|---|---|---|---|---|
| B-1 | 3-13-13 | New Basin Sludge Pump East of Settling Tanks | 145 | 25 | NE[3] |
| B-2 | 3-13-13 | New Sludge Pump Pipeline NE Corner of Settling Tanks | 144 | 7 | NE |
| B-3 | 3-13-13 | New Sludge Pump Pipeline SE Corner of Settling Tanks | 149 | 7 | NE |
| B-4 | 3-13-13 | New Sludge Thickener Tank And Sludge Pump Station | 156 | 25 | NE |
| B-5 | 3-14-13 | Dewatering Building (Future Site) | 157 | 25 | NE |
| B-6 | 3-14-13 | South of Existing Pump Station | 170 | 6 | NE |
| B-7 | 3-14-13 | Between Upper and Lower Ponds | 160 | 20 | NE |
| B-8 | 3-13-13 | Adjacent to New Forcemain between New Sludge Storage and Upper Pond | 149 | 7 | NE |
| B-9 | 3-13-13 | Packaged Plate Settlers (Future Site) | 139 | 25 | NE |
| B-10 | 3-14-13 | New Chlorine Contact and Mixing Tank | 143 | 25 | NE |

[1] See mapped boring locations in Figure 2, and boring logs in Appendices B.
[2] Elevations are approximate, and based on site map provided by Brown and Caldwell ( 2013)
[3] Groundwater not encountered during drilling.

**Table 2. Partial Summary of Reference Boring Data**

| Reference Boring[1] | Drill Date (m-d-y) | Location[2] | Approx. Ground Surface Elevation[2] (ft) | Total Depth (ft) | Groundwater Depth During Drilling (ft) [Elevation] |
|---|---|---|---|---|---|
| RB-1 | 7-15-87 | SE End of Settling Tanks | 150.0 | 17.5 | NE[3] |
| RB-2 | 7-15-87 | SW End of Settling Tanks | 150.0 | 18.5 | NE |
| RB-3 | 7-15-87 | North of Chemical Tank Farm | 148.0 | 19.5 | NE |
| RB-4 | 7-15-87 | Near Future Flow Splitter | 145.0 | 16.5 | NE |
| RB-5 | 7-15-87 | NE of New Chlorine Contact Tank | 140.0 | 16 | NE |
| RB-6 | 7-15-87 | Near Existing Canal Pump Station | 120.0 | 16.5 | NE |
| RB-7 | 7-15-87 | Near Future Sludge Pumps | 140 | 16.5 | NE |
| RB-8 | 12-3-97 | East of Lower Lagoon | 172 | 30 | NE |
| RB-9 | 12-3-97 | East of Upper Lagoon | 172 | 30 | NE |
| RB-10 | 12-3-97 | North side of 5 MG Tank | 180 | 29.5 | NE |
| RB-11 | 12-3-97 | North Side of 1 MG Tank | 165 | 18 | NE |
| RB-12 | 12-3-97 | SE Side of 5 MG Tank | 174 | 20 | 17 (154) |
| RB-13 | 9-22-05 | NE Corner of Ex. Pump Station | N/A[6] | 12.5 | NE |
| RB-14 | 9-22-05 | North End of Ex. Pump Station | N/A[6] | 30 | NE |

[1] See mapped reference boring locations in Figure 2 and reference boring logs in Appendix D.
[2] Elevations are based boring logs by ENGEO (1987) and ENGEO (1997).
[3] Groundwater level reported on boring logs by ENGEO (1987) and ENGEO (1997). NE = Not encountered.
[4] Reference test borings RB-1 and RB-9 by ENGEO (1987) for the 1987 City of Pittsburg Water Treatment Expansion.
[5] Reference test Boring RB-10 through RB-12 by ENGEO (1997) for the 6 Million Gallon Water Storage Reservoir at the City of Pittsburg's Water Treatment Plant.
[6] Reference test borings RB-13 and RB-14 by Berlogar Geotechnical Consultants) for the Proposed Pump for West Leland Zone A Reservoir.
[7] Elevation not shown on logs.

## 2.3 Laboratory Tests

Moisture content, unit weight, Atterberg limits (i.e., liquid limit and plasticity index), grain size analysis, unconfined compression, and direct shear were performed on samples retrieved from the project test borings to evaluate their physical characteristics and engineering properties. The results of these tests are summarized on the logs of the borings in Appendix B, and as test result figures in Appendix C

## 2.4 Historic Developments

Historic developments and features at the Project site are illustrated on topographic maps and on aerial photographs provided in Figure 3 and include the following:

- The WTP was constructed in the Pittsburg hills. The 1908 topographic map shows a northward draining creek along the western portion of the WTP site (i.e., in the area of the present day ponds).
- The 1908 topographic map shows a north trending ridge sloping to the north along the eastern portion of the WTP site.
- Construction of the Contra Costa Canal prior to 1945.
- Site grading and construction of original WTP structures (e.g., original sedimentation basin) on the north trending ridge circa 1953.
- Construction of the existing Lower Pond circa 1953.
- Construction of the residential roadways along the east side of WTP sometime between 1945 and 1953.
- Construction of 6 MG treated water reservoir, filters and booster pumps sometime between 1953 and 1974.
- Construction of  Upper Pond (sludge storage lagoon), expansion of settlement basins circa 1988.
- The existing 6 MG water reservoir was demolished and replaced with new 1 MG and 5 MG water reservoirs in late 1990’s.
- The pump station for reservoir was constructed sometime after 2005.

It is important to note that (1) past cut and fill grading for existing WTP structures; (2) open-cut excavation for construction of existing and abandoned structures and utilities included vertical or sloped sidewall excavations; and (3) structure bedding and backfill, utility bedding and trench backfill materials for existing and abandoned utilities typically include non-cohesive granular materials, such as sands and gravel.

## 2.5 Geology

The Project site is located near the toe of northwest trending Pittsburg hills. Surface geology and mapping by Helley and Graymer (1997) and by Welch, L.E (1977) and the U.S. Natural Resources Conservation Soil Conservation Service (2012) of the project area is presented on Figure 4.

With the exception of the Upper and Lower Ponds, which are underlain by alluvial deposits, the majority of the Project site is underlain by the Pleistocene-aged Tulare Formation consisted of poorly consolidated, non-marine, gray to maroon siltstone, sandstone, and conglomerate. The Tulare Formation encountered in the test borings consisted primarily of medium dense to dense clayey sands, clayey sands to poorly-graded sands, silty sands, and clayey sands with gravel lean clay.

Welch, L.E and the U.S. Natural Resources Soil Conservation Service mapped the upper 4 feet of the soils at the WTP site to be Altamont soil complex (Figure 5). The Altamont soil complex consists of lean clay with Atterberg Limits with Liquid Limits ranging from 40 to 50 and Plasticity Indices ranging from 25 to 30 (i.e., moderate to high plasticity). Between 4 to 6 feet moderately cemented paralithic bedrock (i.e., weakly consolidated and weakly-to moderately-cemented rock) was mapped.

The descriptions of the near surface soil and bedrock deposits in the project area by the U.S. Geological Survey and the U.S. Soil Conservation Service are consistent with the soil and poorly consolidated Tulare Formation (soil-like formation) we encountered in Project test borings (see Appendix B).

## 2.6 Groundwater

Free groundwater was not encountered during drilling of the project borings or measured within the project bore holes at the end of drilling of the project borings. Boring B-7, which was drilled on the berm between the upper and lower pond, did encountered very moist lean clay with sand between about 13 feet and 20 feet (i.e., bottom of boring).

With the exception of Reference Boring RB-12, located at the southeast side of the 4 MG Tank, which noted groundwater at 17 feet, no groundwater was noted on the reference borings which were drilled to depths ranging from 16 to 30 feet.

## 2.7 Contaminated Soil and Groundwater

No unusual odors or obvious signs of contamination were noticed during drilling of the project test borings. Evaluation of soil and groundwater contamination at the Project site is outside the scope of this geotechnical investigation.

## 2.8 Seismicity

### 2.8.1 Faulting

No active faults cross the Project site. The location of the Project site relative to known seismogenic faults in the San Francisco Bay area is illustrated in Figure 6. The nearest fault to the Project site is the Greenville Fault located approximately 4.5 kilometers to the south.

The Project site is outside of the State of California’s Special Earthquake Fault Zone study areas. Therefore, per the 1972 Alquist-Priolo Earthquake Fault Zoning Act, there is no State-required special earth fault study required at the Project site (Hart and Bryant, 1997). The Act requires that, for a fault to be considered active, its location must be sufficiently well-defined and show evidence for surface displacement during Holocene time (i.e., the last approximately 11,000 years).

### 2.8.2 Ground Shaking

The Project site will be subject to ground shaking from earthquakes on the Greenville Fault, Concord-Green Valley Fault, Mt. Diablo Thrust Fault, Hayward Fault, Calveras Fault and other faults (Figure 6) and distant seismogenic faults. Paleoseismic studies by the Working Group on California Earthquake Probabilities (WGCEP 2007) indicate that there is a 62% probability that one or more large (>6.7 magnitude) earthquake will occur on a fault in the San Francisco Bay area in 30 years.

The peak ground acceleration at the Project site during an earthquake with a 10% probability of being exceeded in 50 years (i.e., a seismic recurrence interval of one event in 475 years) is reported to be about 0.45g (where “g” is the acceleration of gravity; see Figure 7). Average peak accelerations in excess of 0.45g are correlative to ground shaking intensities of Modified Mercalli Intensity between VIII and IX (Figure 8).

Damages attributed to Modified Mercalli Intensity of VIII include slight in specially designed structures, considerable in ordinary substantial buildings with partial collapse, great in poorly built structures, panel walls thrown out of frame structures, fall of chimneys, fall of factory stacks, fall of columns, fall of monuments, fall of walls, heavy furniture overturned, sand and mud ejected in small amounts, changes in well water and persons driving vehicles disturbed.

Damages attributed to Modified Mercalli Intensity IX include ground cracked conspicuously, underground pipes broken, reservoirs threatened, buildings shifted off foundations, damage considerable in specially designed structures, and well-designed frame structures thrown out-of-plumb.

### 2.8.3 Liquefaction and Lateral Spreading

Liquefaction develops when cyclically induced ground stresses generated by earthquake shaking result in an increase in the pore water pressure within the soil to sufficient levels that the soil loses shear strength and liquefies. Liquefied soils compact (settle) as pore pressures decrease to static levels and soil particles reconfigure to denser packing. Studies of liquefaction in the area by the U.S. Geological Survey (Knudsen and others, 2000, and Witter and others, 2006) did not identify any areas of historic liquefaction in the project area (e.g., as a result of the 1906 San Francisco earthquake or the 1989 Loma Prieta earthquake). Soils most susceptible to liquefaction are loose, saturated, clay-free, noncohesive silts and sands within 30 feet of the ground surface.

Based on the soil and groundwater conditions underlying the Project site (as described in project and reference boring logs), the native soils underlying the Project site have a low susceptibility to liquefaction in a major nearby earthquake. This is consistent with the liquefaction susceptibility maps of the area by ABAG (2011).

Liquefaction-induced lateral spreading is the finite lateral displacement of gently sloping ground at the result of pore pressure build-up or liquefaction in a shallow underlying deposit during an earthquake. The Project site has a low susceptibility to liquefaction; therefore, the soils underlying the Project site have a low susceptibility for liquefaction-induced lateral spreading.

# 3 Conclusions

It is our professional engineering opinion that the planned Project is feasible from a geotechnical engineering standpoint. The geotechnical data collected in the project area (presented in Section 2 and Appendices B through D) do not pose any geotechnical-related fatal flaws to the project. Nonetheless, the subsurface conditions require special attention and coordination by designers and contractors in order to design and construct the project in a safe and economic manner and to ensure the project's useful long-term performance.

The following is a summary of geotechnical challenges for the planned Project:

## 3.1 Structures and Piping

- Sloping excavations and trenches for below-grade structures and piping.
- Shoring of vertical-wall excavations and trenches for below-grade structures and piping.
- Vertically and laterally variable soil and fill behavior in excavations. These include running of existing structure and pipeline backfill materials and native sands.
- Proper compaction of structure foundation bedding and backfill to provide adequate foundation support.
- Proper compaction of pipeline foundation bedding, embedment, and trench backfill materials to provide adequate pipe support and to minimize trench settlement.
- Unidentified, buried, man-made obstructions.
- Potential debris in fill.
- Possible local perched groundwater.
- Soil corrosivity.

## 3.2 General Geotechnical Considerations

- Construction vibrations
- Seismic ground shaking

In Section 4, we provide considerations and recommendations to facilitate design, construction, and useful long-term performance of the new structures and pipelines with respect to these and other geotechnical-related impacts at the project site.

# 4 Recommendations

Geotechnical engineering recommendations provided herein are for design, construction, and useful long-term performance of the Project. The recommendations are based on geotechnical findings provided in Section 2 and geotechnical interpretations and conclusions. The contractor selected to construct the project should be made solely responsible to choose the appropriate construction means, methods, and monitoring so that during and as a result of project construction (1) no one is injured; (2) no nearby existing structure, improvement, or utility is damaged; and (3) the project is constructed as designed and provides for useful long-term performance.

## 4.1 Anticipated Groundwater Level

A total of ten boring were drilled for the Project and fourteen reference borings were drilled for previous projects (see Table 2 in Section 1.1.) at the Project site. The borings were drilled to depths ranging from 6 to 30 feet and only one boring (i.e., Reference Boring RB-12) encountered groundwater and the groundwater level in RB-12 was at a depth 17 feet.

The planned Project structure bottom depths and pipeline invert depths are less than 14 feet. As such, groundwater is not anticipated on an area wide basis. Groundwater may locally be encountered in project excavations at shallower depths than was recorded in project borings and reference, particularly where granular backfill for existing utilities is encountered and adjacent to upper and lower ponds. Perched groundwater should locally be expected within coarse-grained granular backfill of existing utility trenches and structures. Final design of temporary dewatering and shoring must be based on actual field conditions at the time of construction.

## 4.2 Site Preparation

Existing vegetation (e.g., grasses, weeds, brush, trees), root systems, utilities, and structures within the planned improvement areas should be removed from the site. Resultant holes created by removal of these objects should be cleared of all loose material and dished to provide access for compaction equipment. Overexcavated areas should be backfilled with crushed Caltrans Class 2 aggregate base (Class 2 AB) and be compacted to 95% relative compaction per ASTM D1557. Class 2 AB should meet the material properties and quality tests in Table 3, below

**Table 3. Class 2 AB**

| Class 2 AB | | |
|---|---|---|
| Sieve Size | Percent Passing | |
| 1" | 100 | |
| 3/4" | 90-100 | |
| No. 4 | 35-60 | |
| No. 30 | 10-30 | |
| No. 200 | 2-9 | |
| Test | California Method No. | Requirement |
| Resistance (R-Value) | 301 | 78 min. |
| Sand Equivalent | 217 | 22 min. |

## 4.3 Temporary Excavations

Based on our understanding of the project as outlined above, we anticipate that temporary construction excavations will include:

- Excavations for below grade structures.
- Open-cut trenching for 8-inch Sludge Forcemain and other buried pipelines and conduits.

Accounting for foundation bedding thickness, the excavation depths for the project structures will be 15 feet deep or less. It is our understanding the trench excavations for the new Sludge Forcemain will be 4 feet deep.

All excavations should be evaluated for stability prior to entry by personnel by the contractor's designated "competent person." The contractor should comply with governing regulations pertaining to excavation safety (e.g., the most current edition of the Cal/OSHA Construction Safety Orders, or other regulations adopted by City of Pittsburg).

Project excavations will require shoring, sloping, and/or ground improvement. The contractor should be solely responsible for such systems' design, installation, performance, and removal (where applicable). Because these systems are interdependent, it should be required that proposed dewatering, shoring, and ground improvement submittals be coordinated and provided together by the contractor for owner review prior to their implementation. The submittals should contain alternative, contingent systems that the contractor will be prepared to implement should the initial construction excavations not achieve the minimum performance requirements described herein.

### 4.3.1 Excavatability

Excavations into fill and native soils such as those encountered in the project test borings, reference test borings, and mapped in the project area as described in Section 2 can be made with appropriately sized conventional excavation equipment (standard excavators and/or backhoes). The project specifications should require that contractors preparing bids thoroughly inspect all surface conditions and soils, including fills, along and near the project. Contractors must independently evaluate the excavatability of the subsurface soil to be encountered during project construction and make their own choice of appropriate excavation equipment and methods. The project specifications should require that contractors submit excavation plans (methods and equipment) for owner review prior to mobilization.

### 4.3.2 Excavation Sloping and Shoring

Sloped excavations and shored excavations are anticipated for the below-grade structures (e.g., sludge pump station behind sedimentations basins, gravity thickener, thickener sludge pump station) and below-grade pipelines (e.g., sludge forcemain). The project specifications should make the contractor solely responsible for the selection, design, construction, removal, and effects of project shoring systems. All excavations made into the subsurface should be evaluated for stability by the contractor's competent person prior to entry by personnel. A professional civil engineer licensed in the State of California should design, sign, and stamp the contractor's proposed sloping and shoring systems for owner review prior to construction. The shoring submittals should contain alternative contingent systems, and the contractor should be prepared to implement these alternative systems should the initial systems not achieve the following minimum sloping and shoring performance requirements:

- Protect personnel that enter the excavation.
- Comply with all governing regulations pertaining to excavation safety (e.g., the most current edition of Cal/OSHA Construction Safety Orders, Article 6).

- Be compatible with the subsurface soil and groundwater conditions encountered in the project area and resist lateral earth pressures.
- Protect existing utilities, pavements, and structures.
- Excavation, sloping, and installation of shoring must occur in a manner and sequence that does not damage existing structures, pavements, and utilities including through settlement, heave, or vibrations.
- Prevent running and raveling or lateral movement of excavation slopes and walls, and associated loss of adjacent ground and adjacent ground surface settlement, including when subjected to construction vibrations.
- Provide stable excavation slopes, walls, and bottom.
- Allow for removal or abandonment of shoring in a manner and sequence that (1) is in step with the backfilling sequence (i.e., shoring should not be removed ahead of backfilling); (2) does not cause disturbance (i.e., loosening) of subsurface material; and (3) does not damage the new and/or existing structures, pavements, and utilities (this includes through settlement, heave, and vibrations). The specifications should require that the contractor address removal/abandonment concerns specific to the type of shoring proposed in its shoring submittal (e.g., static sheet pile extraction). Any void space created by shoring removal should be completely filled with controlled low strength material (CLSM) (Section 4.6.3) or approved equivalent.
- Resist lateral earth pressures including those from hydrostatic pressures (groundwater where not dewatered), lateral loads from vehicular traffic, construction equipment and spoils.

Soil conditions can vary over short lateral and vertical distances in the project area; therefore, project excavations should be continually monitored and documented by the contractor’s Cal/OSHA approved “competent person,” and the contractor should be prepared to make changes and modifications to sloping and shoring requirements in response to these changes and consistent with governing regulations (e.g., the most current edition of Cal/OSHA Construction Safety Orders) pertaining to excavation safety. Cal/OSHA soil classifications include the following:

**Type A Soil:** Excludes materials that are part of a sloped or layered system dipping into the excavation at a slope ≥ 4H:1V, but includes cohesive soil with an unconfined compressive strength of ≥ 1.5 tsf that is:

- Not fissured;
- Not subject to vibration from heavy traffic, pile driving, or similar effects; and
- Not been previously disturbed.

**Type B Soil:** Excludes material that is part of a sloped or layered system dipping into the excavation at a slope ≥ 4H:1V, but includes the following:

- Cohesive soil with unconfined compressive strength between 0.5 and 1.5 tsf
- Angular gravel and silt;
- Previously disturbed soil, except that is otherwise classified as Type C;
- Soil fissured or subject to vibration and not otherwise Type C soil; or
- Dry rock that is not stable.

**Type C Soil:** Excludes material that is part of a sloped or layered system dipping into the excavation at a slope ≥ 4H:1V, but includes the following:

- Cohesive or disturbed soils with unconfined compressive strength ≤ 0.5 tsf;
- Sand and nonangular gravel;
- Submerged soil or soil from which water is freely seeping; or
- Submerged rock that is not stable.

The existing trench and structure backfill, area wide fill, and native soil encountered in the project area during this investigation typically most closely could be classified as Cal/OSHA Type B and C. The final decisions as to the Cal/OSHA's soil type classification in project excavations are field decisions to be made at the time of excavation by qualified and competent field personnel of the contractor.

Excavation side slopes are to be protected from erosion and surface water runoff. The maximum temporary slope inclination (horizontal:vertical) that is allowed by Cal/OSHA without supporting design by a professional engineer for Type C soil is 1.5H:1V. Cal/OSHA also requires that temporary excavation slopes greater than 20 feet be designed by a professional engineer. Cal/OSHA defines the maximum allowable slope as the steepest incline of an excavation face that is acceptable for the most favorable site conditions (i.e., assuming no adjacent soil stockpile or heavy equipment) as protection against cave-ins.

Contractors and their excavation/shoring designers are to acknowledge Cal/OSHA requirements and develop their own assessment of safe temporary slope inclinations is a field decision to be made at the time of excavation by the contractor's "competent person".

Preliminary design of braced shoring may be based on the preliminary shoring pressure diagram provided in Figure 9, which represents typical soil conditions, mapped and encountered in project test borings. Final earth pressures and pressure diagrams for the contractor's design and implementation of individual project shoring systems will be dependent on (1) the actual soil and groundwater conditions encountered during construction; (2) the contractor's shoring type, design, and installation method; (3) the contractor's dewatering system, if needed; and (4) surcharge pressures, including those from stockpiling, construction equipment, and vehicular traffic. Surcharge pressures, where present, need to be added to the lateral earth pressures recommended in Figure 9. Minimum shoring pressures from typical traffic and construction equipment surcharge loads are presented in Figure 10. Shoring pressures from construction activities or equipment that produces larger or different surcharge loading patterns than those shown in Figure 10 should be determined by the shoring designer using appropriate geotechnical engineering computational methods.

Granular noncohesive materials (e.g., sandy native soils and/or sandy and gravelly artificial fill and/or sandy and gravelly import fill used as utility trench bedding and backfill) tend to flow or fast ravel when saturated and run or ravel when dry (i.e., have little to no stand-up time in unshored vertical excavations). See Appendix A, Figure A-1 for descriptions of soil behavior. In such instances and where the minimum performance requirements for shoring listed above cannot be met, full-face, continuous excavation wall support will be required.

Intermittent speed shores or trench-box shoring will not be appropriate in running or raveling ground conditions as they will not meet the minimum recommended performance requirements. Furthermore, running, and raveling ground will have insufficient strength and stand-up time to safely hold full-depth vertical excavations long enough for complete trench box or solid sheet-backed, speed-shore installations (particularly when subject to construction vibrations). Solid sheeting is required by Cal/OSHA in Type C soil. Unsupported vertical excavations in running or raveling ground will most likely experience excavation wall loss and related undermining of adjacent utilities, and structures. Trench boxes should only be used for trenches where groundwater is below the base of the planned excavation, and only if excavation occurs from within the box as it is lowered incrementally into place and in step with the deepening excavation (i.e., so as to provide continuous full-face excavation side-wall support).

Shoring systems that do not provide positive support of excavation walls (i.e., passive shoring, such as trench boxes, that allows inward movement of the trench wall) could cause surface settlement and related damage to nearby utilities and structures. A summary of the potential surface settlement of passively shored excavations is provided in Table 4. Unrestricted flowing, running, or raveling ground conditions will result in surface settlements greater than those indicated in Table 4.

**Table 4. Potential Surface Settlement of Passively Shored Excavations[1]**

| Soil Type | Surface Settlement (% of Excavation Depth) | Lateral Zone of Disturbance (Multiples of Excavation Depth) |
|---|---|---|
| Sand | 0.5%H | H |
| Soft to Medium Stiff Clay | 1–2%H | 3–4H |
| Stiff Clay | <1%H | 2H |

[1] From Suprenant and Basham (1993).

Special shoring will be necessary where excavations will be in close proximity to critical structures or utilities in order to minimize potential excavation-related damage. Special shoring and/or grout stabilization designs should be submitted by the contractor for owner review where excavations are within an imaginary plane projected downward at an inclination of 1.5H:1V from the nearest foundation edge. Areas requiring special shoring and/or ground improvement designs should also receive preconstruction condition surveys specific to the critical structure or utility.

## 4.4 Site Preparation for Structures

The following new structures planned for construction:

- Chlorine Contact and Mixing Tank
- Sludge Thickener Tank
- MCC Building
- Settled Sludge Pump Station
- Thickened Sludge Pump Station
- Forcemain from Thickener to Upper Pond
- Upper Pond Partition Wall

Findings, conclusions and recommendations for the Upper Pond Retaining Wall will be provided as an addendum to this report after the pond sludge is removed and the subsurface exploration is completed.

### 4.4.1 Site Preparation - At-Grade Structures

The Chorine Contact Tank, Thickened Sludge Pump Station, MCC Building foundations are at-grade structures (i.e., structures whose foundation bottoms are located approximately 1 foot below existing grade). These at-grade structures are underlain by dry to moist, stiff to hard, moderately expansive clays having plasticity indices of ranging from 22 to 30. Structure foundations underlain by the existing moderately expansive soils could be susceptible to differential foundation settlement due to seasonal shrink-swell ground movements which can result in out-of-level structures and potential foundation and wall cracks.

To mitigate seasonal differential foundation movement due to seasonal shrink and swell of the underlying expansive clays, it is recommended that the upper three feet of soil below the foundation bottom extending 2 feet beyond the perimeter of the foundation be over-excavated. The bottom of over excavation should be scarified to a depth of 8 inches and compacted to a minimum 90% relative compaction at moisture content over 3% of optimum moisture content per ASTM D1557. The over excavation should be backfilled with non- to very low expansion potential material to a depth of 12-inches below the foundation bottom. The non- to very low expansion potential material should meet the gradation and quality recommendation in Table 5, below.

**Table 5. Non-Expansive to Very Low Expansion Material**

| Sieve Size | Percent by Weight Passing Sieve |
|---|---|
| 3 in. | 100 |
| 3/4 in. | 60–100 |
| No. 4 | 40 to 100 |
| No. 200 | 10-40 |
| **Test** | **California Method No. Requirement** |
| Plasticity Index | NP-12 |
| Liquid Limit | Less than 30 |
| Expansion Index (UBC 18-2) | Less than 20 |

### 4.4.2 Site Preparation - All Structures

A 12-inch thick layer of Caltrans Class 2 AB should be placed below the structure bottoms. Prior to placing Class 2 AB, the subgrade should be scarified to a minimum depth of 8 inches and compacted to a minimum of 90% relative compaction. The Class 2 AB should be crushed rock and should meet the gradation and quality properties provided in Table 3.

## 4.5 Foundation Recommendations

The planned structures should be designed using the following criteria.

### 4.5.1 Allowable Soil Bearing Capacity for Structure Foundations

The mat foundations for the new structures should be a minimum of 8 inches thick steel reinforced concrete. Actual thickness should be determined by the project Structural Engineering based on design criteria (i.e., subgrade reaction, Poissons's ratio, Young's Modulus provided in Section 4.5.2 below). Allowable bearing capacities for structures founded on mat foundations are presented in Table 6, below.

**Table 6. Allowable Bearing Capacity for Mat Foundations**

| Structure | Allowable Bearing Capacity |
|---|---|
| Chorine Contact and Mixing Tank | 2,000 psf |
| Sludge Thickener Tank | 2,500 psf |
| MCC Building | 1,500 psf |
| Settled Sludge Thickener Pump Station | 2,500 psf |
| Thickened Sludge Pump Station | 2,000 psf |

At-grade structures founded on a perimeter spread footing foundation system can be designed with an allowable bearing capacity of 2,500 psf. Spread footing foundations should a minimum of 24 inches wide with a minimum embedment depth of 18 inches below the lowest adjacent undisturbed subgrade. Any footing located adjacent to the other footings or utility trenches should have their bearing surface situated below an imaginary 1.5 horizontal to 1.0 vertical plane projected upward from the bottom edge of the adjacent footing or utility. Footings located above this imaginary plane will require further evaluation of surcharge effect. All spread footing foundations should be designed with top and bottom steel reinforcement to provide structural continuity and to permit spanning over irregularities.

The allowable soil-bearing pressures can be increased by one-third for transient loading such as wind and seismic forces.

### 4.5.2 Modulus of Subgrade Reaction, Poisson's Ratio, and Young's Modulus

Mat foundations may be designed for an average modulus of subgrade reaction ($k_1$) of 100 tons per cubic foot for a unit square foot. The structural engineer should modify the modulus of subgrade reaction for the mat size.

The mat foundations should also be designed for the following soil parameters:

- Poisson's ratio of 0.3,
- Young's Modulus of 250 tons per square foot

### 4.5.3 Heave and Settlement

Some movement of the subgrade soil is anticipated to occur during excavation (unloading) and during construction, and when loads area applied (e.g., filling of tanks).

Heave (rebound) of foundation subgrade will occur during excavation of below grade structures due to a reduction of the load on the subsoil below the excavation. We estimate a rebound at the center of the below-grade structures of less than ½ inch. The majority of the heave will occur immediately upon excavation.

Assuming the foundation soils consist of medium dense to dense sand and compacted non-expansive to low expansive material and Class 2 AB, the mat contact pressures are equal to the recommended allowable bearing capacity, and there is no significant disturbance to the excavation subgrade during excavation, we estimate that the maximum settlement at the center of the below-grade structural mat foundations will be on the order of ½ inch or less and the maximum settlement at the center of the at-grade structures will be on the order of 1 inch or less for the Chorine Contact and Mixing Tank and on the order of ½ inch or less for the smaller at-grade structures (e.g., MCC Building, Thickened Sludge Pump Station)

### 4.5.4 Coefficient of Sliding Friction

An allowable coefficient of sliding friction of 0.35 times dead load may be used for mat foundations founded on a minimum of 12 inches of Class 2 AB material.

A coefficient of sliding of 0.30 times the dead load may be used at the base of spread footing foundations founded on non- to very low expansion potential material.

In addition, for portions of the foundation that extend below the adjacent pavement, an allowable passive pressure of 300 pounds per cubic foot can also be used to resist lateral forces.

### 4.5.5 Below-grade Structure Backfill Materials

Where there is sufficient space between the structure wall and the excavation side wall in which to mechanically compact the backfill (i.e., where small remote control and walk behind compaction equipment can be used), we recommend that the excavation be backfilled with Class 2 AB (see Table 3).

The Class 2 AB backfill should be compacted in lifts no greater than 8 inches in loose thickness to a minimum of 95% relative compaction at a moisture content at or near optimum (ASTM D1557).

Under no circumstances should jetting of backfill be required. Subsurface structure walls should be braced as necessary during backfill compaction to prevent displacement and damage while backfill is placed. The contractor should also choose compaction equipment that will not exert damaging forces on the structure walls.

Where there is not adequate space to properly compact aggregate backfill (e.g., space between structure walls and shoring is less than 2 feet wide or there is piping through the structure walls), or at convenience of the contactor, controlled low-strength material (CLSM) may be used as backfill. CLSM is a hand-excavatable, free-flowing and self-compacting material that should consist of cement, pozzolan, fine and course aggregates, and water that has been mixed in accordance with ASTM C94. The CLSM should have a minimum 28-day compressive strength of not less than 50 psi and a maximum 28-day compressive strength of no more than 150 psi. The CLSM should also have a minimum 12-hour compressive strength of no less than 20 psi. Placement of the backfill, pavement section, or concrete on top of the CLSM should not be allowed until the CLSM passes the ball drop test described in ASTM D6024.

### 4.5.6 Lateral Earth Pressure on Below-Grade Structure Walls

Static at-rest lateral earth pressures, as well as potential seismic lateral loads will be imposed on all subsurface structures, including the walls of the Settled Sludge Pump Station, Sludge Gravity Tank, and portions of the Thickened Sludge Pump Station. The recommended lateral earth pressures for the design of the below grade structure walls are presented on Figure 11. A coefficient of sliding friction of 0.35 can be used at the base of the mat foundations. Lateral loads produced by transient loading (e.g., vehicular traffic) need not be considered in the design unless the lateral load produced by transient loads exceeds the dynamic earth pressure.

### 4.5.7 Lateral Earth Pressure on Retaining Walls

Retaining walls whose tops are not free to deflect should be designed for at-rest conditions (refer to Section 4.5.6 above). The following design criteria apply to retaining walls whose tops are fee to reflect, that are a maximum of 10 feet in height with horizontal backfill, and have a drainage system consisting of drain rock with perforated drain pipes or weep holes to prevent hydrostatic pressures that might be caused by groundwater or water trapped behind the retaining wall.

Retaining walls designed are meet the criteria above can be designed for the active and passive earth pressures in Table 7, below.

**Table 7. Lateral Earth Pressures on Retaining Walls**

| Earth Pressure Conditions | Non-Expansive to Very Low Expansion Material | Undisturbed On-Site Clay |
|---|---|---|
| Active | 35 | 50 pcf |
| Passive | 400 | 275 pcf |

Jacobs Associates should be consulted for reduced passive earth pressures for design of footings with sloping ground in front of the footing. In addition to passive pressure, a coefficient of sliding friction for neat concrete against non-expansive to very low expansion material of 0.30 times total dead load may be used to resist lateral forces. Lateral loads produced by transient loading (e.g., vehicular traffic) need not be considered in the design unless the lateral load produced by transient loads exceeds the dynamic earth pressure (see Figure 11 for recommended dynamic earth pressure).

## 4.6 Pipeline Bedding and Backfill

The project specifications should require that excavation backfilling and pipe bedding be done in accordance with the requirements of this section, where not exceeded by the City or other governing agency, company, and/or pipe manufacturer requirements. Figure 12 illustrates typical trench excavation backfill details and definitions for this project. References to compaction and optimum moisture content are relative to ASTM D1557 standards.

### 4.6.1 Pipe Embedment Material

If approved by the pipe manufacturer, and so long as placement does not damage the pipe, then the pipe bedding material can consist of crushed Class 2AB uniformly graded within the gradation requirements given in Table 3. Pipe embedment material should be used around the pipe extending a minimum distance of 6 inches below the pipe to 12 inches above the pipe.

### 4.6.2 Excavation Backfill Material

Trench excavations located in paved areas, improved areas and/or areas of future improvements should be backfilled to the finished subgrade with pipeline embedment material.

Trenches in undeveloped, unpaved areas and areas where no future improvements are planned may be backfilled with on-site soil excavated from the trench. The on-site soil used for backfill should be free of contamination, vegetation and other deleterious materials and contain no material greater than 3 inches in size, including earth clods. Moisture conditioning of on-site soils (drying wet and saturated soils and wetting dry soils) may be required to achieve proper backfill compaction.

### 4.6.3 Controlled Low Strength Material (CLSM)

Where existing utilities cross the trench excavations and trench backfill cannot be properly compacted below the existing utility, CLSM (see Section 4.5.5) should be used to backfill below the existing utilities.

CLSM should be placed in appropriate lifts or with methods to prevent flotation and/or movement of the pipe. The contractor should install approved anchor blocks or deadman concrete collars as needed to secure the pipe in place.

CLSM should not contain physiochemical properties that damage the pipe.

Placement of backfill, pavement section or concrete on top of CLSM should not be allowed until the CLSM passes the ball drop test of ASTM D6024.

### 4.6.4 Compaction

Relative compaction and optimum moisture content referred to herein is to be determined by ASTM D1557 unless stated otherwise.

All water which accumulates in the bottom of the excavations must be removed so that the work can be done in dry conditions. Pipe bedding material (i.e., pipe zone material below the pipeline invert) should be compacted to a minimum of 90% relative compaction at a moisture content at or above optimum. The pipe bedding material must be compacted to a smooth, uniform, horizontal plane.

After pipe placement, the pipe embedment material should be uniformly placed in maximum 8-inch thick loose lifts on each side of the pipe and hand-shovel sliced around the pipe haunches to support the sides of the pipe and prevent pipe displacement. Each loose lift on the sides of the pipe should be mechanically compacted to a minimum of 90% relative compaction. No jetting of pipe bedding material should be allowed. After the pipe embedment material has been placed to a level 12 inches above the top of the pipe, the surface should be mechanically compacted to achieve a minimum of 90% relative compaction (i.e., mechanical compaction equipment should not be placed directly over the top of the pipe until at least 12 inches of pipe bedding material has been placed over the top of the pipe).

In unpaved areas, native excavation soils used as excavation backfill should be placed in maximum loose lifts of 8 inches and compacted by mechanical compaction to a minimum of 90% relative compaction and moisture content at or above optimum moisture content. In paved areas, Class 2AB used as excavation backfill should be compacted to a minimum of 90% relative compaction to within 24 inches of the pavement subgrade and 95% relative compaction within the upper 24 inches of backfill. No jetting of excavation backfill (either native soil or Class 2AB) should be allowed.

#### 4.6.5 Recompression Settlement

The total amount of pipeline settlement will depend mostly on the condition of the trench and excavation bottoms (i.e., determined by the contractor’s performance in achieving the minimum recommendations for trench and excavation bottom stability, as stated herein). Therefore, it is imperative that stable trench and excavation bottoms are maintained at all times and that loose, disturbed or otherwise softened soils are not allowed in the trench or excavation bottoms. Backfill loading upon such soils can produce random settlements (much greater than 1 inch) that can be abrupt.

Excavation for proposed pipelines will be backfilled to their original grade, and the compacted backfill will exert no significant additional loads onto the underlying undisturbed soil deposits. Therefore only elastic deformation (i.e., recompression) of the native materials induced by backfill placement is anticipated. Elastic deformation will occur quickly upon load application. The maximum recompression of undisturbed trench excavation bottoms (less than 5 feet wide) should be less than ½ inch and should occur upon backfilling. The maximum differential recompression between differing undisturbed soil types along the project area should be less than ¼ inch.

Special attention is required where excavation widths are larger than common trenches (i.e., more than a few feet wider than the pipeline), since in such cases the loading on the pipe would be based more on embankment conditions. Pipe loading under embankment conditions is considerably greater than under trench conditions. Specific evaluation of pipe loading in excavations should be made based on the specific geometry of the excavation and the pipeline placement.

### 4.6.6 Backfill Compression

Backfill placed within excavations will compress (settle) by self-weight, even when well compacted. We estimate that settlement of granular trench backfill materials compacted as recommended in this report, will be less than 0.2 to 0.4 percent of their thickness. Where excavations are located beneath paved surfaces, the finished pavement will reflect this backfill settlement. Settlement will be greater than these estimates where native soils are used as excavation backfill. For native soils backfill, settlement by self-weight will be on the order of 1.0 to 2.0 percent of their thickness.

### 4.6.7 Vertical Loads on Pipe

Vertical loads applied to project pipelines will consist of dead loads imposed by trench backfill and intermittent live loads imposed by vehicle traffic. Design criteria for live loads on the pipeline from vehicular traffic (H-20 loading) are provided in Figure 13.

### 4.6.8 Rigid Pipe

The following Marston formula (Moser, 2008) may be used to estimate the vertical soil loads on rigid pipes placed in backfilled trenches. The vertical load is dependent on the width of the trench (B) in feet:

$$W = C \gamma B^2$$

where:

$W$ = Vertical soil load on rigid pipe due to trench backfill (lb/ft),
$\gamma$ = Unit weight of compacted backfill
- 125 pcf for compacted native soil
- 150 pcf for Class 2 aggregate base or CLSM backfill,

$C$ = Marston's coefficients for trench (t) conditions, presented graphically in Figure 14 for different trench depth (H) to width (B) ratios (i.e., H/B).

### 4.6.9 Flexible Pipe

Dead loads due to backfill soil overburden on a flexible pipeline assuming trench conditions can be estimated using the following Prism Method–based formula (Moser, 2008):

$$W = D \gamma H$$

where:

$W$ = Vertical soil load on a flexible pipe (pounds/foot),
$D$ = Pipe outside diameter (feet),
$\gamma$ = Unit weight of compacted backfill
- 125 pcf for compacted native soil
- 150 pcf for Class 2 aggregate base or CLSM backfill,

$H$ = Height of trench backfill above the pipeline (feet).

Special attention is required where excavation widths are larger than common trenches (i.e., more than a few feet wider than the pipeline) since in such cases the loading on the pipe would be based more on embankment conditions. Pipe loading under embankment conditions is considerably greater than under trench conditions. Specific evaluation of pipe loading in excavations should be made based on the specific geometry of the excavation and the pipeline placement.

### 4.6.10 Composite Modulus of Soil Reaction ($E'_c$)

Vertical loads on a flexible pipe cause the pipe to decrease in vertical diameter and increase in horizontal diameter. The horizontal movement develops a passive resistance, which helps to support the pipe. The composite modulus of soil reaction ($E'_c$) is useful for estimating the passive soil resistance that will develop in a trench for flexible pipes. $E'_c$ is a function of the soil modulus of the pipe zone material ($E'_{pz}$), the soil modulus of the trench wall material ($E'_{tw}$), trench width, depth of cover, and pipeline diameter (see Figure 15). $E'_{pz}$ and $E'_{tw}$ are in turn a function of the strength of each material.

For this project, we have recommended that all pipeline embedment zones be backfilled using compacted Class 2AB or CLSM. As a result, $E'_{pz}$ for Class 2AB and CLSM will be roughly constant at approximately 1,500 psi. It is imperative that properly compacted pipe zone material not be disturbed or loosened by shoring removal in order to maintain these minimum $E'_{pz}$ values. $E'_{tw}$, however, will vary depending if the yard piping is within new engineered fill or native soils.

Based on project test borings, a typical $E'_{tw}$ value for native soils would range from 500 psi to 1,000 psi within the upper 10 feet to 1,000 psi and above once deeper. A typical $E'_{tw}$ value for engineered fill is 1,000 psi. Table 8 presents values for $E'_{tw}$ for different soil types. Using these values, and the trench width to pipeline diameter ratio, the soil support combining factor $S_c$ can be determined from Figure 15 and then used to calculate $E'_c$ based on the formula [$E'_c=S_cE'_{pz}$] from Jeyapalan (2001).

**Table 8. $E'_c$ Calculation Parameters**

| **$E'_{pz}$ (psi) for CLSM or Compacted CL2AB**[a] | **$E'_{tw}$ (psi)** | | **$E'_{tw}:E'_{pz}$ Ratio** |
|---|---|---|---|
| 1,500 psi | Medium stiff or loose soil (4<N<8)[b] | 250 psi | 0.17 |
| | Stiff or loose to medium dense soil (8<N<15) | 500 psi | 0.33 |
| | Very Stiff or medium dense soil (15<N<30) | 1,000 psi | 0.67 |
| | Hard or dense soil (N>30) | 2,000 psi | 1.33 |

[a] Pipeline embedment material specified and compacted as recommended in this report.

[b] N = ASTM D1586 Standard Penetration Blow Count.

The composite modulus of soil reaction ($E'_c$) can be calculated for the various outside diameters of the pipe (D) and the various minimum design trench widths (B) using the following equation developed by Jeyapalan (2001):

$$E'_c = S_cE'_{pz}$$

The soil support combining factor $S_c$, which is a function of $E'_{pz}$, $E'_{tw}$, and B/D, is given in the table presented in Figure 15. For example, for an $E'_{pz}$ of 1,500 psi for embedment material and an $E'_{tw}$ of 250 psi for trench wall soil, $E'_{pz}/ E'_{tw} = 0.17$. For a pipe with an outside diameter (D) of 12 inches and a 24-inch wide trench (B), the B/D is 2. Using the table in Figure 15, $S_c = 0.41$. Therefore, $E'_c = S_cE'_{pz} = 0.41 \times 1{,}500$ psi = 615 psi.

## 4.7 Asphaltic Concrete Roadways

Preliminary pavement recommendations for new asphalt concrete paving are provided in Table 9 for Traffic Indices ranging from 4.0 to 6.0 using the Caltrans Flexible Pavement Design Method and assuming an R-value of 5. A traffic index of 4.0 represents light vehicles, and a traffic index of 6.0 represents truck traffic. The District and project designer should evaluate which level of use best represents the project and select an appropriate Traffic Index for final design.

The traffic indices presented herein should be considered preliminary since we do not presently have information with respect to anticipated vehicle loading and repetitions. For example, the pavement section may need to support heavy equipment during the proposed construction. Additional recommendations for higher or lower Traffic Indices can be provided upon request. Final pavement structural sections should be designed at the completion of rough grading when (1) representative samples of the pavement subgrade can be taken and R-value tested in the laboratory, and (2) final Traffic Indices are selected by the City and/or Brown and Caldwell.

**Table 9. Preliminary Asphalt Concrete Pavement Sections**

| Traffic Index | Asphalt Concrete (ft) | Aggregate Base (ft) |
|---|---|---|
| 4.0 | 0.20 | 0.65 |
| 5.0 | 0.20 | 0.95 |
| 6.0 | 0.25 | 1.15 |

New pavement construction should also meet the following criteria:

- The upper 12 inches of soil subgrade should be compacted to a minimum of 95% relative compaction and be at or near optimum moisture content.
- Class 2AB material should be compacted in lifts no greater than 8 inches in loose thickness and compacted to 95% relative compaction.
- Pavements should be sloped and drainage gradients maintained to carry all surface water to storm drain inlets or other existing site drainage facilities.
- Ponding should not be allowed anywhere on site.
- An adequate drainage control system should be provided to prevent surface water or groundwater seepage from saturating the subgrade soils.
- The asphalt concrete materials should conform to the specifications stated in Section 39 of the State of California Standard Specifications, latest edition or equal.

Pavement sections should be prepared assuming that periodic maintenance will be required, including sealing of cracks and other measures.

## 4.8 Surface Drainage

Surface drainage provisions should be incorporated into the design for the structures. The drainage provisions should be carefully designed to redirect all surface water off-site and away from slopes, foundations, and base-rock pathways beneath pavements. Site drainage should be redirected into a closed underground collector pipe network that connects to appropriate storm drain facilities. Water should not be allowed to pond and seep into the soils anywhere on the site, and it should not be directed to flow uncontrolled over adjacent slopes.

## 4.9 Construction Vibrations

The project will be constructed in native soils and existing fills and backfills that will transmit construction vibrations to existing nearby surface and subsurface structures (including utilities and pipelines). Therefore, the type and operation of equipment to be used during project construction should be selected by the contractor to limit construction vibrations (a function of frequency and peak particle velocity) to levels that will not damage (1) existing surface structures and improvements; and (2) existing subsurface structures including utilities, pipelines, and nearby residences.

A commonly accepted damage threshold criterion for high frequency peak particle velocity vibrations at existing surface structures and improvements is on the order of 1.0 to 2.0 inches per second (USBM RI-8507). High frequency peak particle velocities above these values can cause cosmetic damage to structures (e.g., cracking of plaster and drywall). Typical attenuation curves for vibratory sheet pile driving indicate peak particle velocities are generally less than 1 inch per second at distances greater than 20 feet. Pile driving into obstructions or through coarse granular materials (e.g., granular fill or trench backfill) may generate higher than typical peak particle velocity vibrations with greater attenuation distances.

Construction vibrations should be monitored and documented by qualified technicians with approved vibration measuring equipment (seismographs) located at structures nearest the site of actual ongoing construction. Vibration levels greater than 1 inch per second at nearby surface structures will require modification of the contractor’s construction procedures to reduce vibration levels. Photographic precondition surveys of the structures located adjacent to the project area should be performed to establish baseline conditions prior to project construction and to aid in assessing construction damage claims, if any.

## 4.10 Seismic Design

The Project is not crossed by any active fault and is located approximately 4.5 kilometers northeast of the mapped northwest limit of the Greenville Fault. Since the project is not crossed by an active fault, there is very little likelihood of fault rupture.

Regional liquefaction maps indicate that fill soils at the project site have a very low susceptibility (ABAG, 2011). Our site-specific subsurface investigation encountered stiff to hard clays and medium dense to very dense sands above in the upper 8 feet. In addition, groundwater was encountered in none of the project borings and only one of the reference borings logs (i.e., RB-12) encountered at a depth of 17 feet. As a result, we estimate the risk of liquefaction in the fills and native soils is low.

The primary seismic hazard for the project site will be ground shaking. On the basis of historical evidence, it is reasonable to assume that during its lifetime, the project site will be subject to at least one moderate to severe earthquake that will cause strong ground shaking. The effects of ground shaking on the proposed structures and pipelines may be mitigated by design and construction detailing in accordance with the foundation and seismic provisions of the 2010 California Building Code (CBC) as a Site Class C.

# 5 Additional Services and Limitations

## 5.1 Additional Services

All earthwork for the project should be observed and tested by a qualified geotechnical engineer licensed in the State of California. Jacobs Associates should be given the opportunity to provide the following additional services through the completion of project construction:

- Review of plans and specifications prior to bid;
- Review of geotechnical-related contractor submittals (e.g., shoring, excavation sloping, backfill materials, foundation construction, etc.);
- Review of contractor requests for information relating to geotechnical issues; and
- Periodic construction observations of exposed subsurface conditions for conformance to conditions anticipated herein on which our recommendations were based.

These recommended reviews and observations are to evaluate design interpretations, verify submittal assumptions, and observe actual project construction implementation with respect to the geotechnical findings and recommendations provided in this report.

## 5.2 Limitations

This report has been prepared for the exclusive use of Brown and Caldwell and its consultants and contractors in connection with the design and construction of the City’s Water Treatment Plant Capital Improvements Project, which is located in Pittsburg, California. The data presented in this report are based on the subsurface conditions encountered by Jacobs Associates at the time that the geotechnical investigation for the Project was conducted. The report also contains information and data collected from other relevant studies, as well as our professional experience and judgment. Subsurface conditions may vary between exploration locations and with time; as a result, conditions that differ from those summarized in the report, and that are unanticipated, can and do occur. Jacobs Associates is not responsible for the interpretation of the data contained in this report by anyone; as such interpretations are dependent on each person’s subjectivity.

The geotechnical investigations and this report were completed within the limitations of Jacobs Associates’ approved scope of work, schedule, and budget. The services rendered by Jacobs Associates have been performed in a manner consistent with the level of care and skill ordinarily exercised by members of the profession currently practicing under similar conditions in the same area. If differing conditions are exposed during construction or the design is modified, we should be retained to reevaluate the subsurface conditions and provide written confirmation or modifications, as necessary, to this report. Jacobs Associates is not responsible for the use of this report in connection with anything other than the project at the location described above. We recommend any construction budget and schedule contain a contingency to allow for any reevaluation of the contents of this report if warranted.

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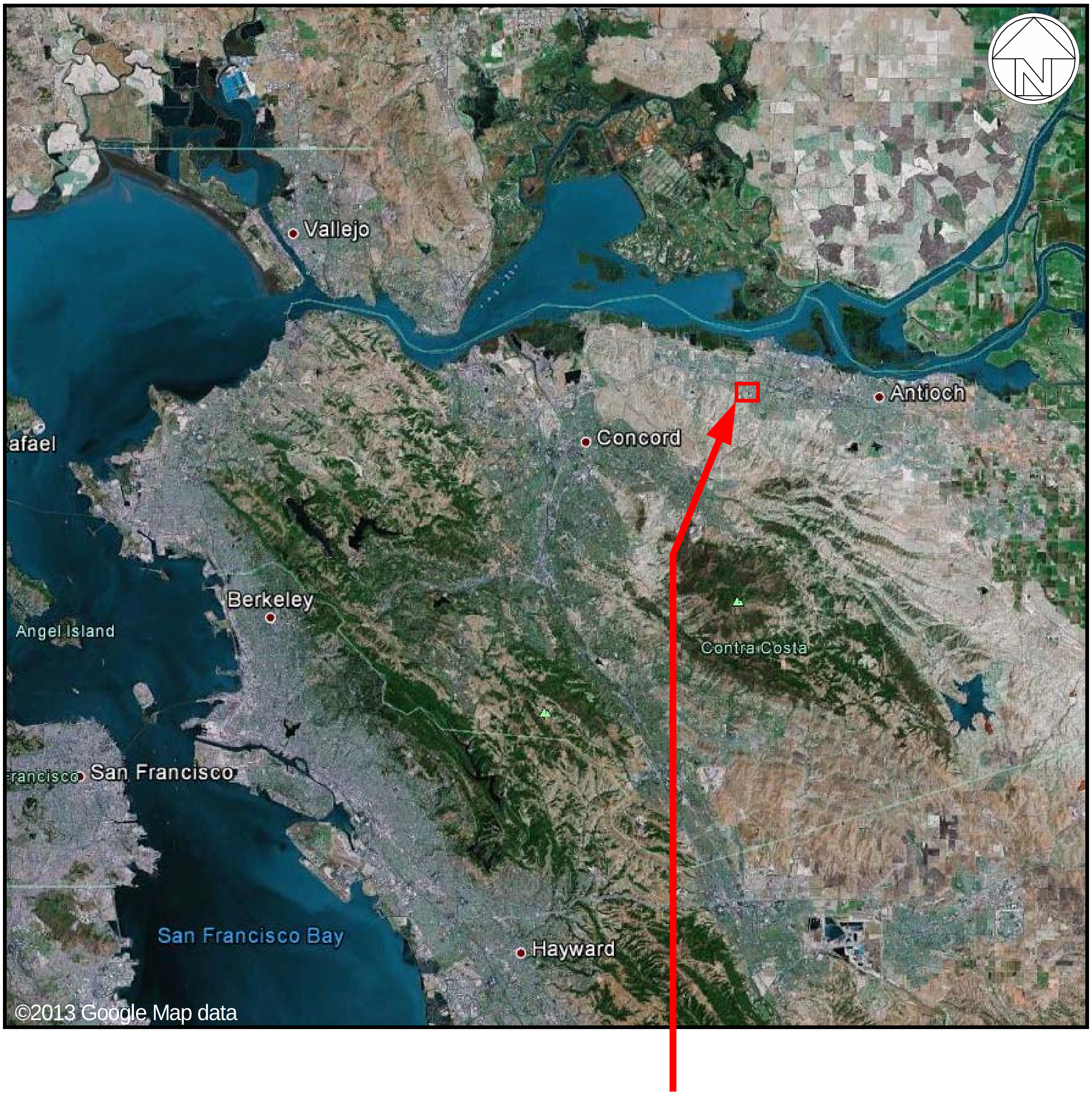
# Figures



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**PROJECT AREA**

JACOBS ASSOCIATES
Engineers/Consultants

File No. 5003.0

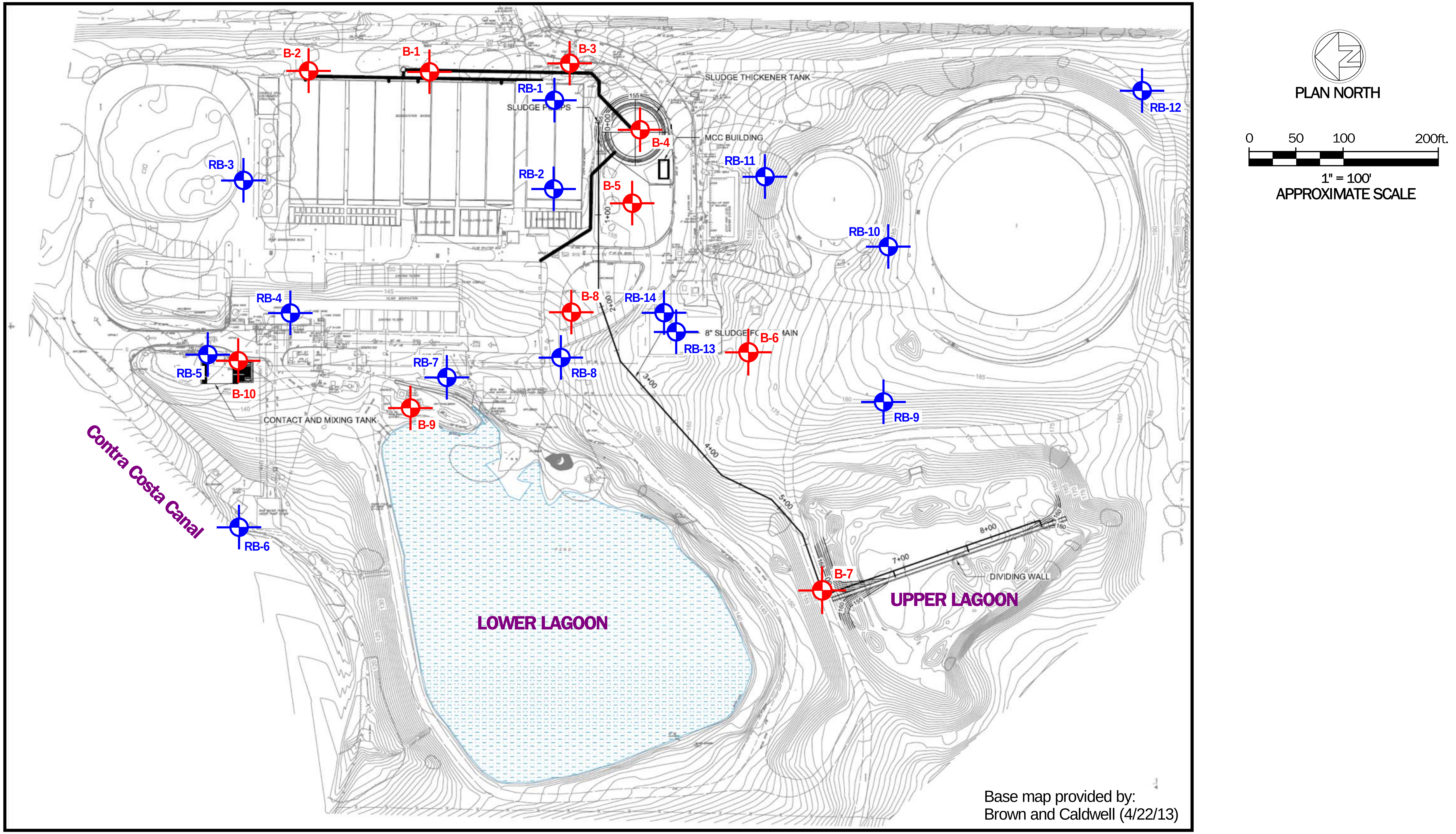
June 2013

**Brown and Caldwell**
City of Pittsburg
Water Treatment Plant Capital Improvements Project
Pittsburg, California

**Project Area Map**

**Figure**

**1**



Base map provided by:
Brown and Caldwell (4/22/13)

**LEGEND:**

⊕ B-1 - Project test boring (logs in Appendix B)

⊕ RB-1 - Reference test boring (logs in Appendix D)

JACOBS ASSOCIATES
Engineers/Consultants

File No. 5003.0
June 2013

**Brown and Caldwell**
City of Pittsburg
Water Treatment Plant Capital Improvements Project
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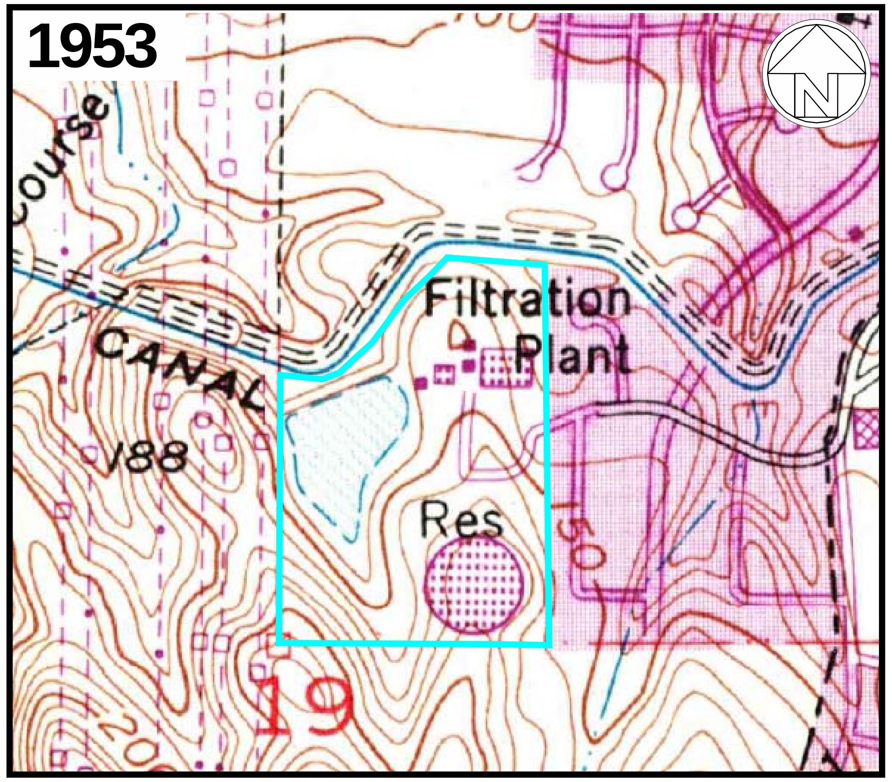
## Boring Location Map

Figure
2

1908

USGS 15 Minute Quadrangle, Pittsburg (1908)

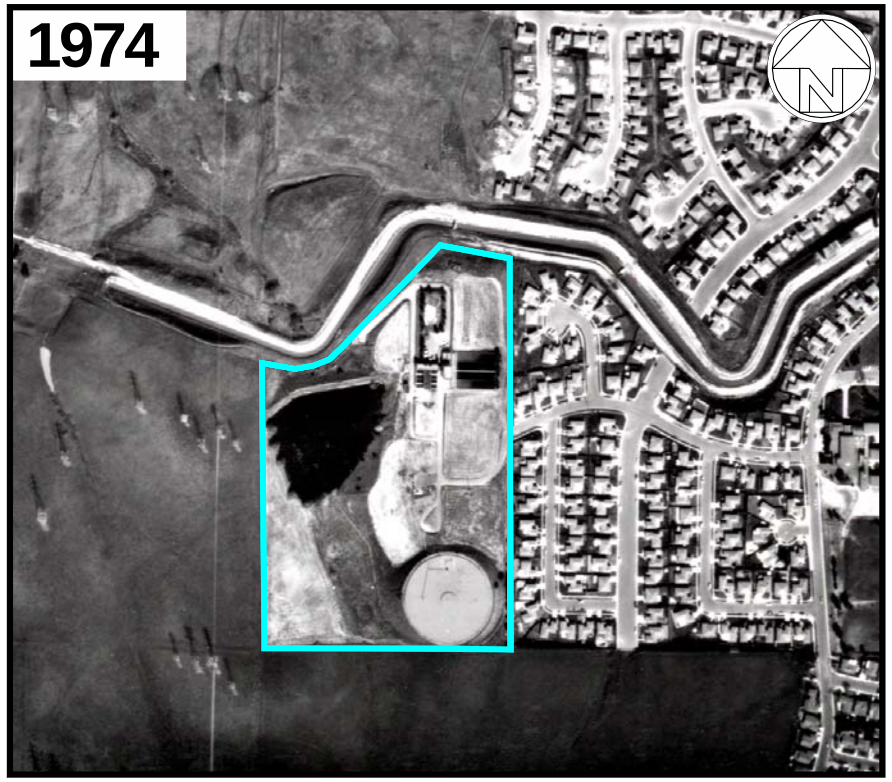


1953

USGS 7.5 Minute Quadrangle, Honker Bay (1953)

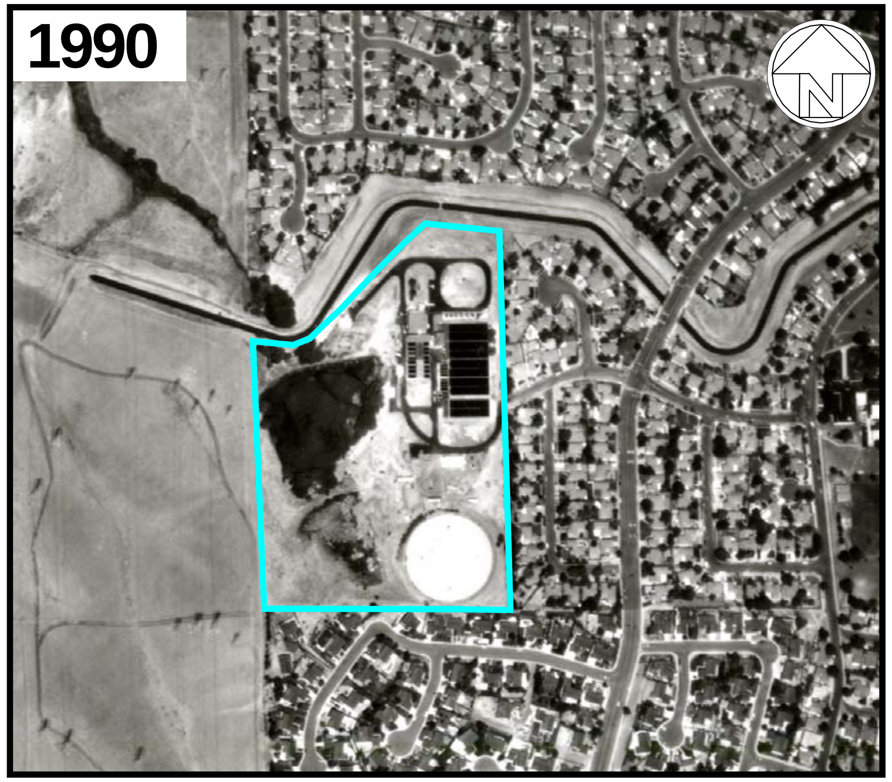
**LEGEND:**

▭ - Approximate outline of Water Treatment Plant



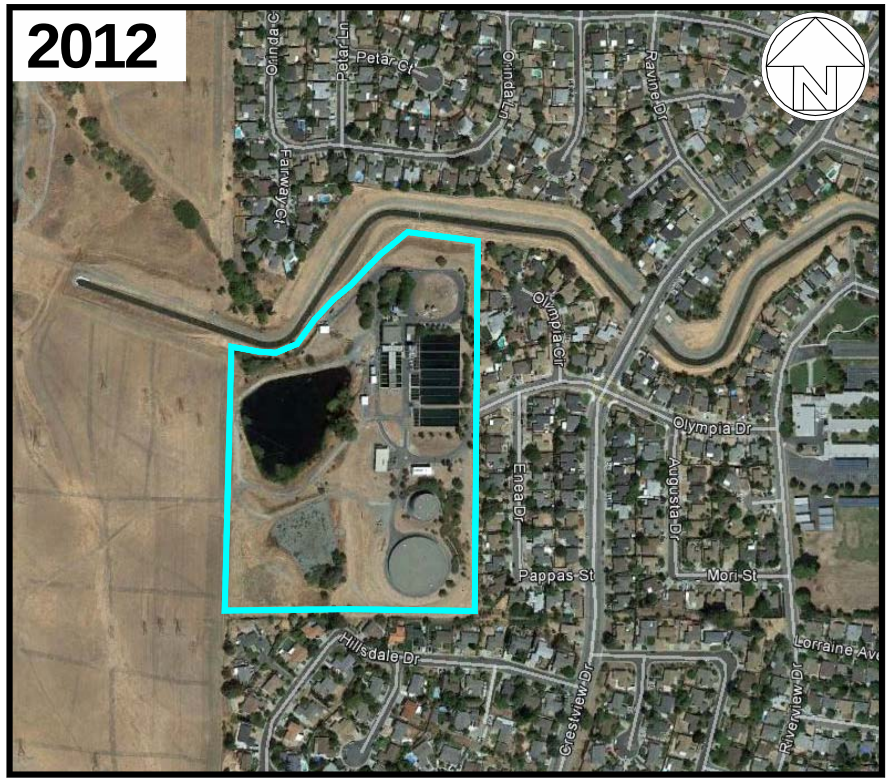
1974

Aerial Photo from Pacific Aerial Survey (1974)



1990

Aerial Photo from Pacific Aerial Survey (1990)



2012

Aerial Photo from Google Earth (2012)

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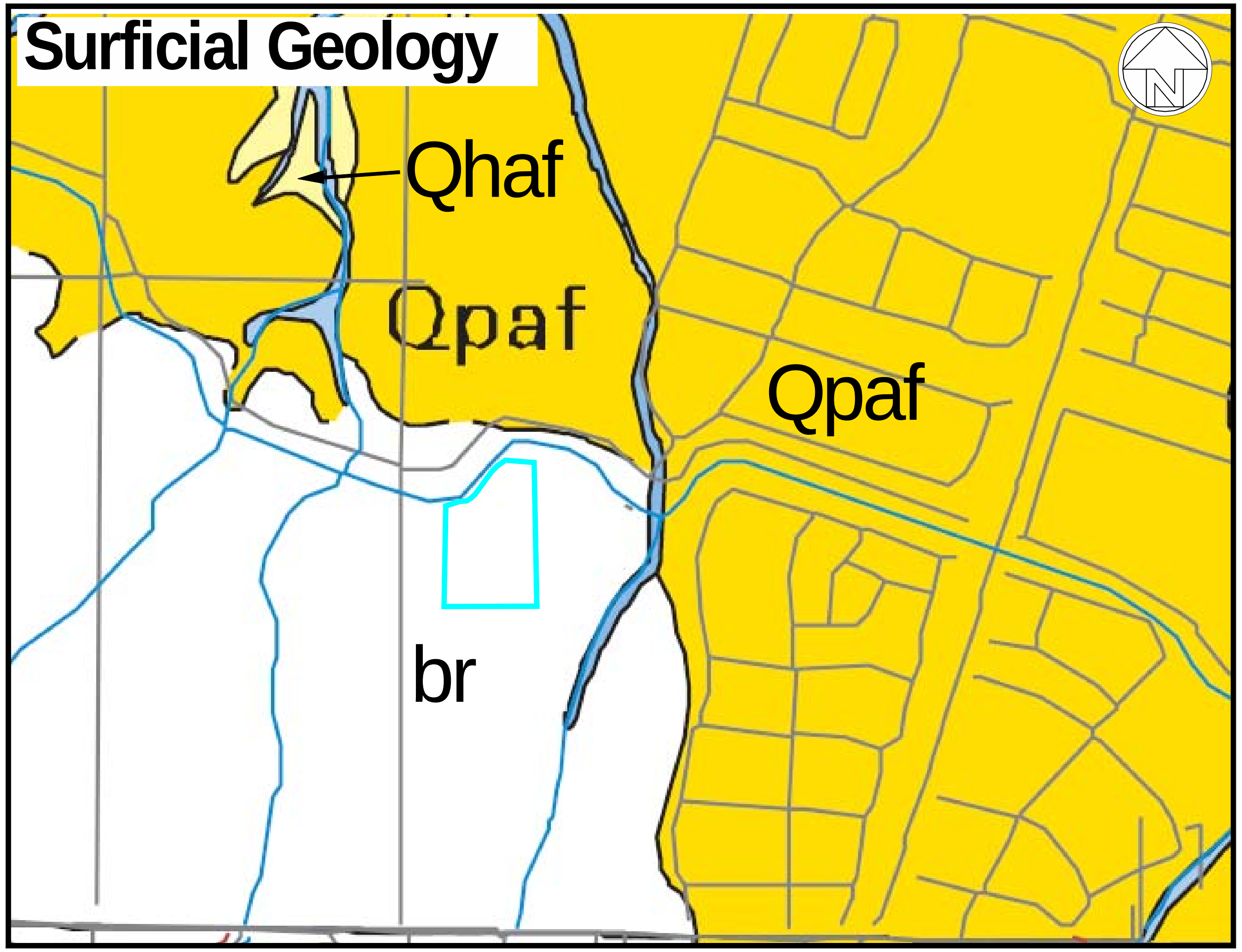
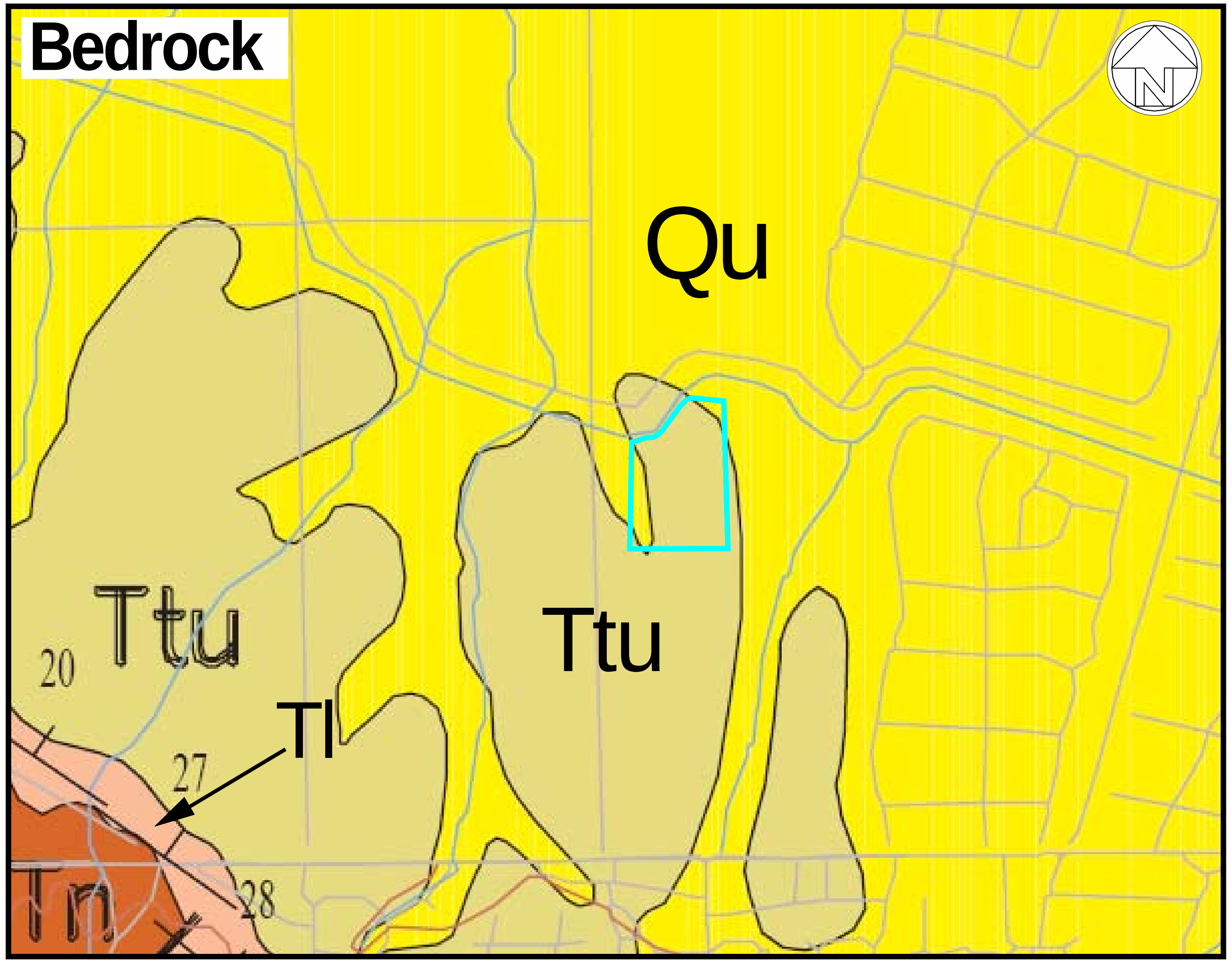
**Historic Topos and Aerial Photos**

Figure
3



Surficial Geology Map and Descriptions from Helley, E.J. and Graymer, R.W. (1997), Quaternary Geology of Contra Costa County, California, and Surrounding Areas, U.S.G.S. OFR 97-98



Bedrock Map and Descriptions from Graymer, Jones, and Brabb (1994), Preliminary Geologic Map Emphasizing Bedrock Formations in Contra Costa County, California; U.S.G.S. OFR 94-622

**LEGEND:**

| | |
|---|---|
| br | **Bedrock**<br>- See description under Bedrock Map for more information |
| Qpaf | **Alluvial Fans and Fluvial Deposits (Pleistocene)**<br>- Brown dense gravely and clayey sand or clayey gravel that fines upward to sandy clay. These deposits display various sorting are located along most stream channels. Maximum thickness is unknown but at least 50 meters. |
| Qhaf | **Alluvial Fans and Fluvial Deposits (Holocene)**<br>- Brown or tan, medium dense to dense, gravely sand or sandy gravel that generally grades upward to sandy or silty clay. |

**- Approximate outline of Water Treatment Plant**

**LEGEND:**

| | |
|---|---|
| Qu | **Alluvial Deposits, Undivided (Pleistocene and Holocene)**<br>- See description under Surficial Geology Map for more information. |
| Ttu | **Tulare Formation (Pliocene)**<br>- Poorly consolidated, non-marine, gray to maroon siltstone, sandstone, and conglomerate. |
| Tl | **Lawlor Tuff (Pliocene)**<br>- Non-marine, pumiceous, andesitic tuff. |
| Tn | **Neroly Sandstone (Miocene)**<br>- Blue, volcanic, rich, cross-bedded sandstone and conglomerate; mainly non-marine. |
| 17 | - Strike and dip of bedding. |

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**Surficial Geology and Bedrock Maps**

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Figure
**4**

| Mapped Soil | | Below Ground Depth (in) | USCS Group Symbol | % Passing Sieve: | | Atterberg Limits | | Depth to Bedrock (in) | High Water Table (ft) | Risk of Corrosion | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Id. | Name | | | No. 4 | No. 200 | Liquid Limit | Plasticity Index | | | Uncoated Steel | Concrete |
| AbE | Altamont | 0-48 | CL | 100 | 85-95 | 40-50 | 25-30 | 48[1] | >6 | High | Low |
| CaC | Capay | 0-72 | CL | 100 | 70-95 | 30-50 | 10-30 | >60 | >6 | High | Moderate |

[1] Moderately cemented paralithic bedrock

Soil Map and Descriptions from U.S. Soil/Natural Resources Conservation Service (Welch, L.E. 1977 & NRCS 2012)

⊕ B-1 - Project test boring (logs in Appendix B)

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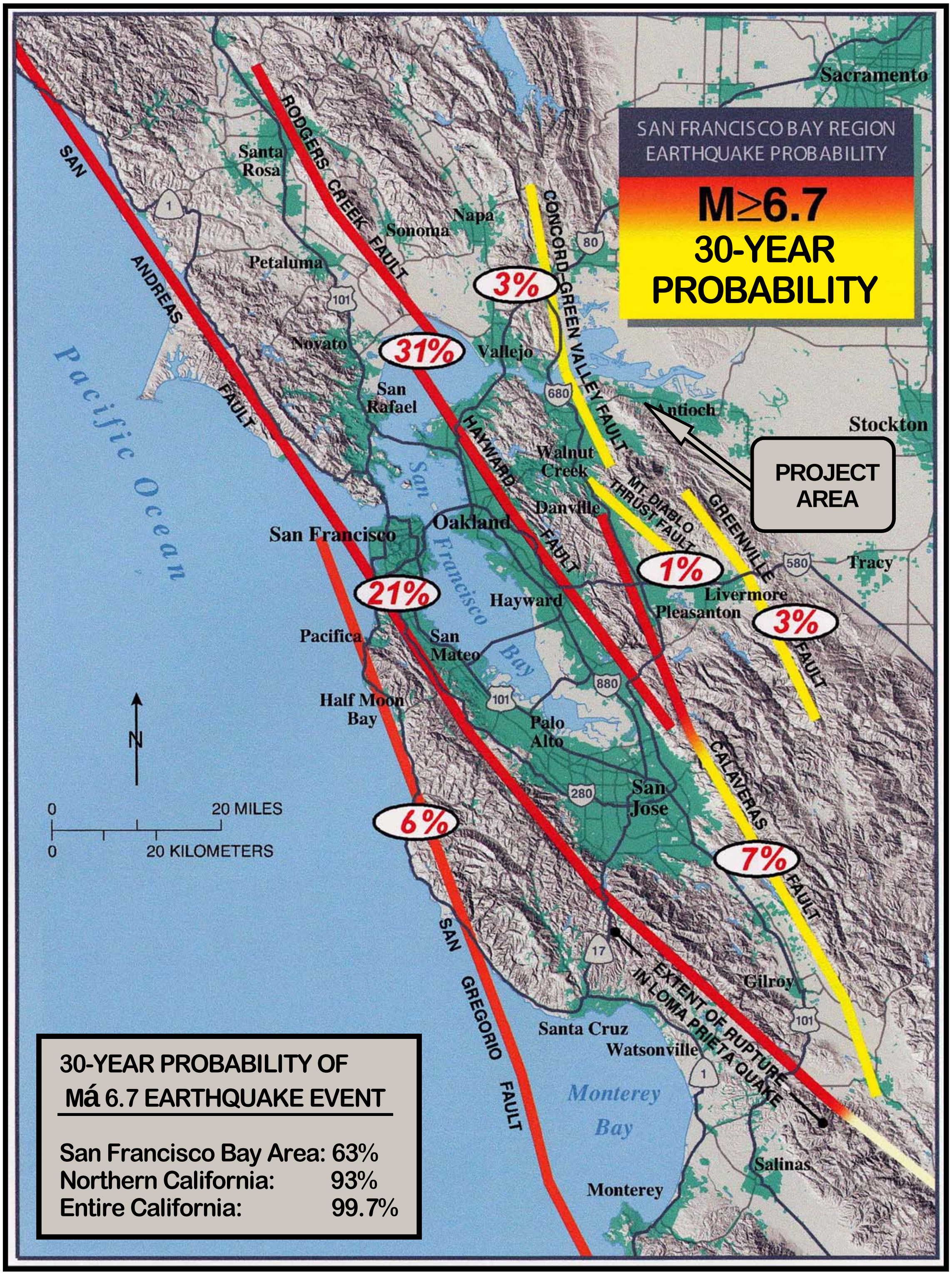
## Soil Map

Figure

5



Map from WGCEP (2003 and 2007)

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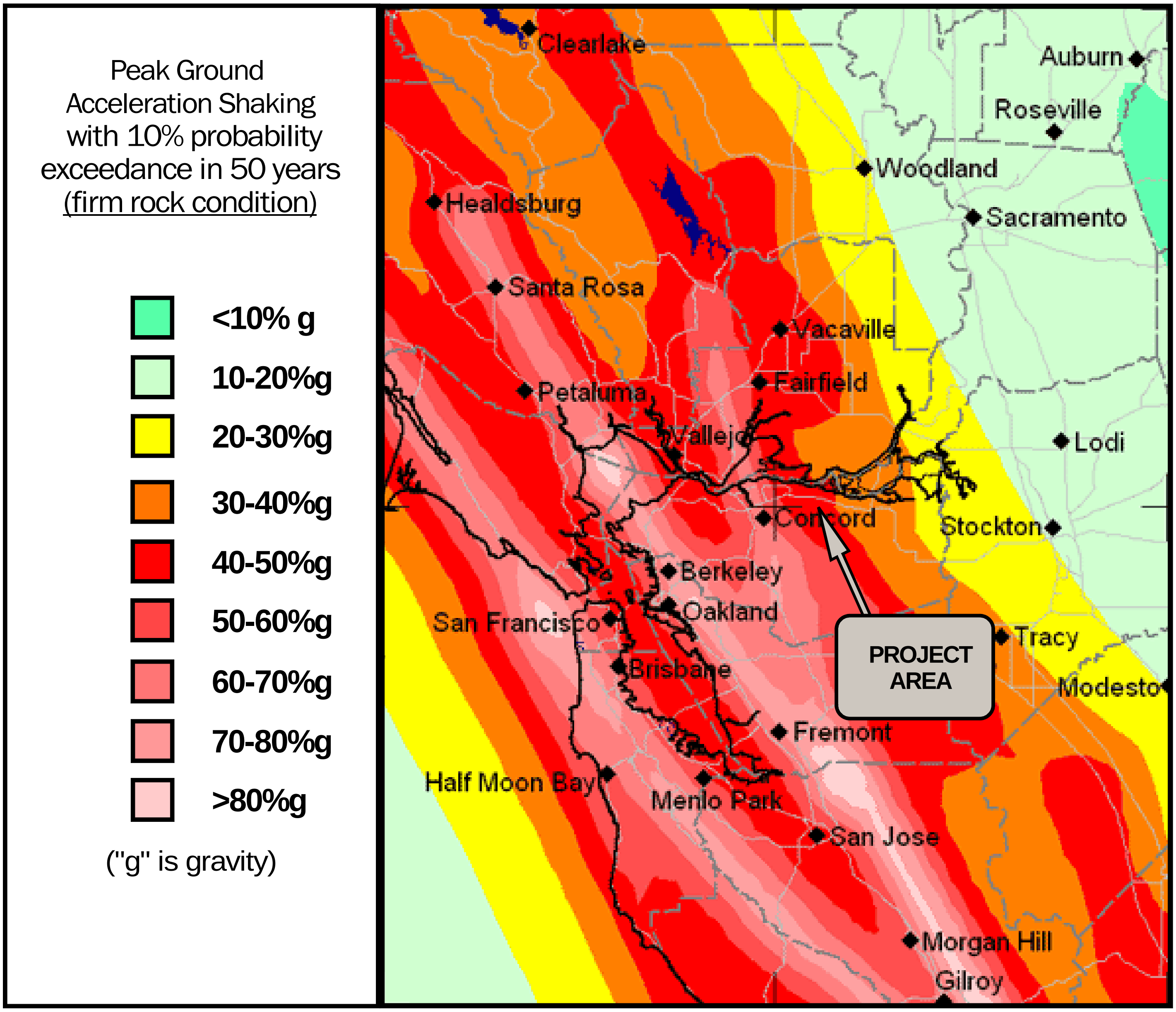
**Bay Area Fault Map**

**Figure**

**6**



Modified from USGS/CGS 2002 Probabilistic Seismic Hazards Assessment Model (Cao and others 2003).

| | |
|---|---|
| **Latitude/Longitude** | N 38.01°/W 121.90° |
| **Peak Ground Acceleration:** | 0.45g |

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**Seismic Shaking Map**

Figure

7

| AVERAGE PEAK VELOCITY (CENTIMETERS PER SECOND) | MODIFIED MERCALLI INTENSITY VALUE AND DESCRIPTION | AVERAGE PEAK ACCELERATION ("g" is gravity - 9.80 meters per second squared) |
|---|---|---|
| | I. Not felt except by a very few under especially favorable circumstances. | |
| | II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing. | |
| | III. Felt quite noticeable indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing vehicles may rock slightly. Vibration like passing of a truck. Duration estimated. | |
| 1-2 | IV. During the day felt indoors by many, outdoors by few. At night some awakened. Rattling of dishes, windows, and doors; walls make creaking sounds. Hanging objects swing. Sensation like a heavy truck passing. Standing vehicles rocked noticeably. | 0.015g-.02g |
| 2-5 | V. Felt by nearly everyone, many awakened. Some dishes, windows and so on broken; cracked plaster in a few places; unstable objects overturned. Disturbances of trees, poles and other tall objects sometimes noticeable. Pendulum clocks may stop. Buildings trembled throughout. | 0.03g-0.04g |
| 5-8 | VI. Felt by all, many frightened and run outdoors. Some moderately heavy furniture moved; a few instances of fallen plaster and damaged chimneys. Trees, bushes, shaken slightly to moderately. Damage slight in poorly constructed buildings. Broken dishes, glassware and some windows. Moved furnishings and overturned furniture. | 0.06g-0.07g |
| 8-12 | VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; chimneys cracked to considerable extent. Noticed by persons driving vehicles. Waves on ponds, lakes, running water. Broke numerous windows, heavy furniture overturned. Dislodged bricks and stones. | 0.10g-0.15g |
| 20-30 | VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving vehicles disturbed. | 0.25g-0.30g |
| 45-55 | IX. Damage considerable in specially designed structures; well-designed frame structures thrown out-of-plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. Reservoirs threatened. | 0.50g-0.55g |
| More than 60 | X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Railroad rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed, slopped over banks. Reservoirs greatly damaged. Open cracks in cement pavements and asphalt road surfaces. | More than 0.60g |
| | XI. Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly. Dams, dikes, embankments severly damaged. Destroyed large well-built bridges. | |
| | XII. Damage total. Practically all works of construction damaged greatly or destroyed. Landslides, falls of rock, slumping of river banks extensive. Fault slips in firm rock, with notable horizontal vertical off-set displacements. Water channels, surface and underground disturbed and modified greatly. Waves seen on ground surfaces. | |

REFERENCE ; Compiled from "Earthquakes & Volcanoes," Volume 21, Number 1, 1989, and "Earthquakes A Primer," Bruce A. Bolt, W.H. Freeman and Company, San Francisco, Copyright 1993.

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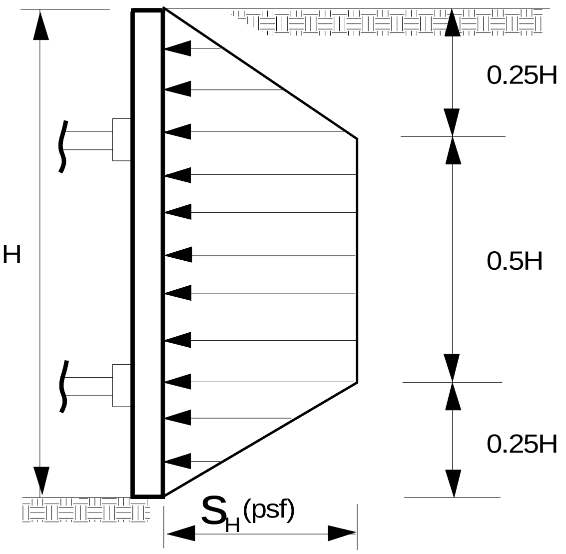
## Modified Mercalli Scale

**Figure**
**8**

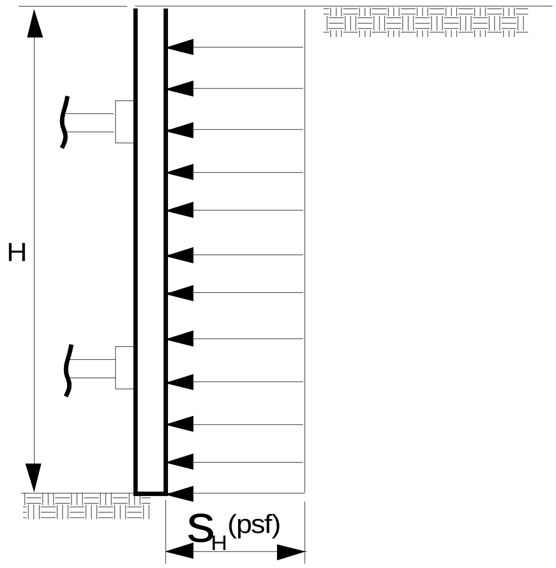
SILT and CLAY PRESSURE DIAGRAM



$S_H$ = 35H psf for stiff to hard silt and clay.

$S_H$ = 40H psf for medium stiff to stiff silt and clay.

SAND, GRAVEL and BEDROCK PRESSURE DIAGRAM



$S_H$ = 25H psf for non-adversely bedded/ fractured bedrock. ②

$S_H$ = 30H psf for medium dense to dense sand and gravel. ②

① These preliminary pressure diagrams are for excavations less than 15 feet in unsaturated soils and bedrock as indicated.

② These preliminary pressure diagrams do not take into account hydrostatic pressures nor the effects of adverse bedrock bedding/fractures, nor stockpiling of trench spoils, excavation equipment, etc. The effects of these conditions must be added to these pressure diagrams where applicable. For example, in the case of adverse bedrock bedding/fractures, the greater of the rock wedge pressure or final design shoring pressure and shoring pressure diagrams should be used for shoring design.

③ Excavation base stability should be analyzed after base width has been selected.

④ Final design shoring pressure diagrams will need to be developed by the contractor based on his selection of shoring system and the actual soil, bedrock and groundwater conditions encountered during construction.

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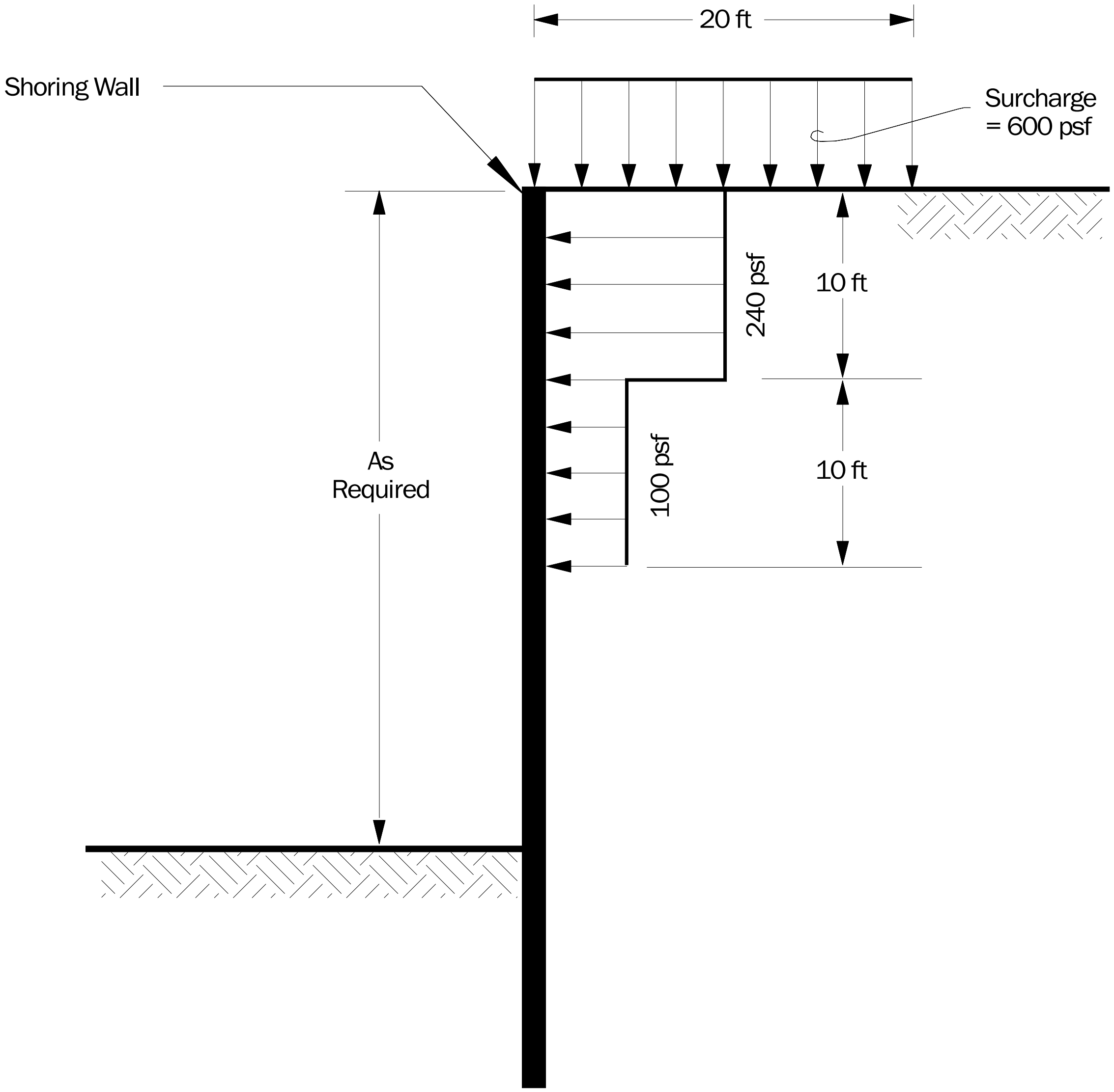
**Preliminary Shoring Pressure Diagrams for Braced Shoring**

**Figure**
**9**



NOTES:

These are minimum shoring pressures to be used for traffic and equipment surcharges. Shoring pressures from construction activities or equipment that produce larger or different surcharge loading patterns than that shown should be determined by the shoring designer using geotechnical computational methods.

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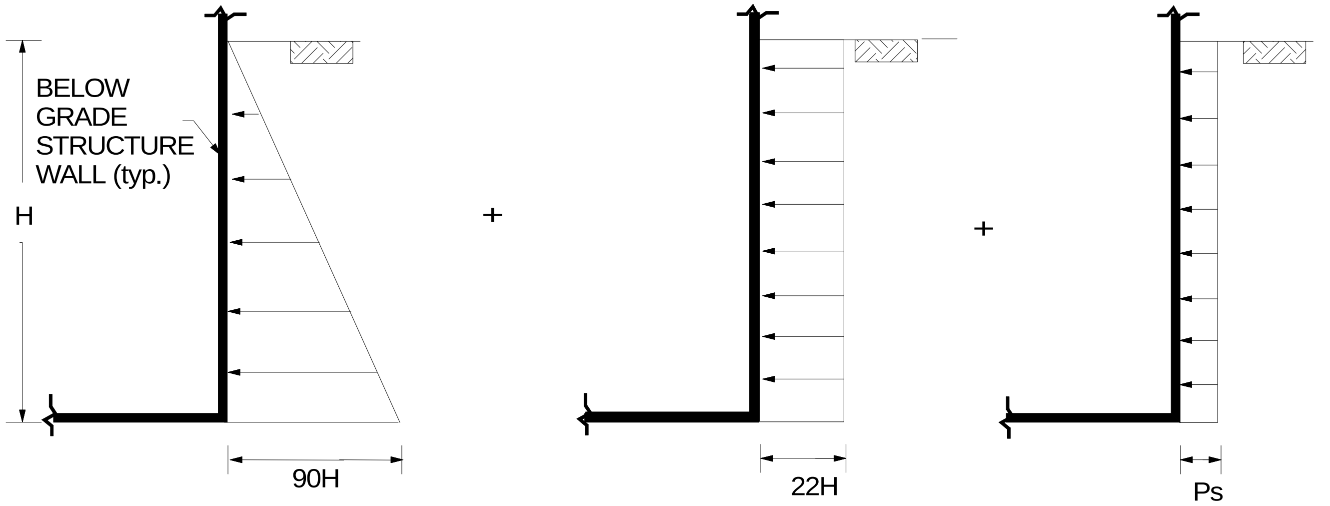
## Minimum Shoring Pressure for Traffic and Equipment Surcharge

**Figure**
**10**



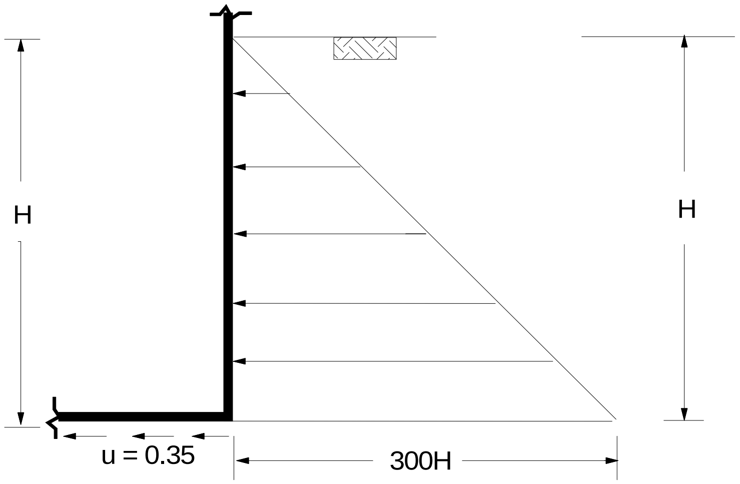
Static At-rest Earth Pressure (Po)
and Hydrostatic Pressure (Pw)

+

Dynamic Pressure (Pe)

+

Surcharge Lateral Pressure (Ps)



Passive Earth Pressure (Pp)*
and Coefficient of Sliding Friction (u)

* Max. Passive Earth Pressure = 3,000 psf

LEGEND:

H = Excavation Height (feet)

Ps = Lateral Surcharge Pressure (psf) from adjacent permanent loads (e.g., structure loads). Diagram shape will vary depending on surcharge load. Temporary lateral surcharge pressure (e.g., stockpiles, equipment, traffic) should be included when they exceed the dynamic pressure (i.e., Pe).

NOT TO SCALE

Note: Earth pressures and coefficient of friction are ultimate values and an appropriate factor of safety should be used in calculations.

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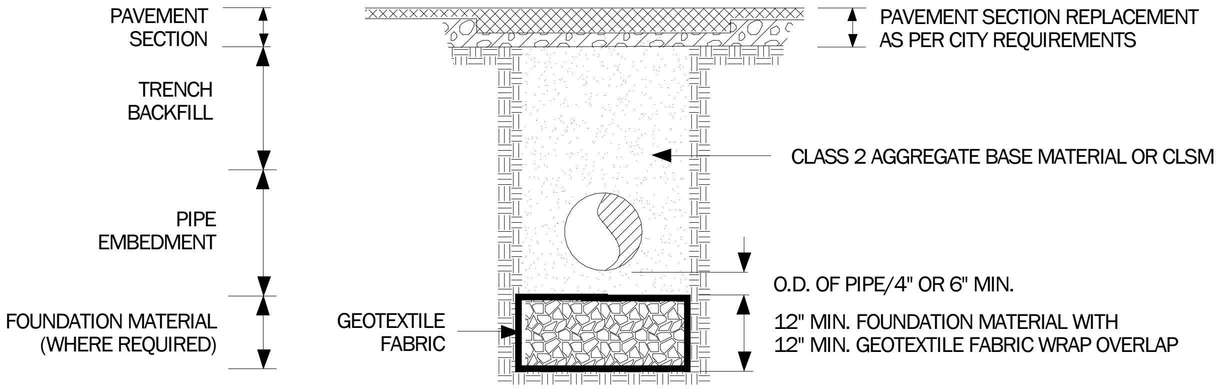
## Lateral Earth Pressures Below-Grade Structures

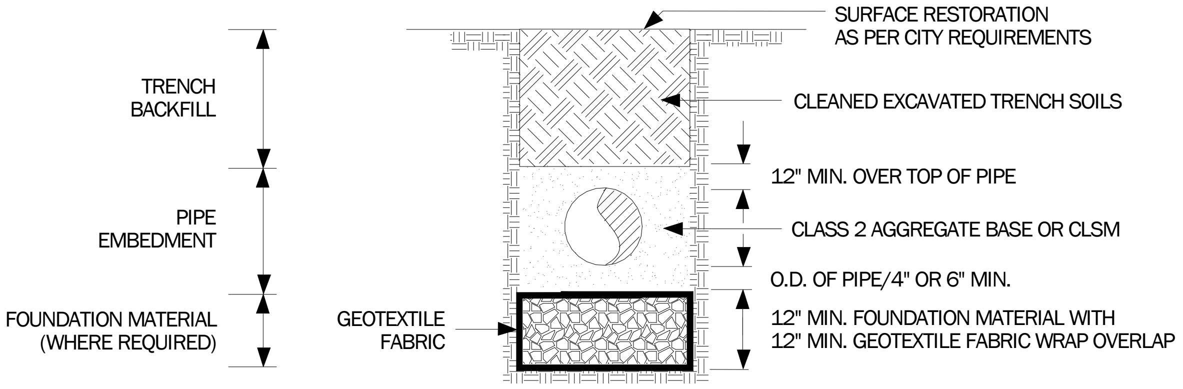
Figure

11

## TRENCH BACKFILL BELOW ROADWAYS & OTHER PAVED AREAS



## TRENCH BACKFILL BELOW AREAS OTHER THAN ROADWAYS & OTHER PAVED AREAS



NOT TO SCALE

SEE TEXT FOR MATERIAL SPECIFICATIONS AND COMPACTION REQUIREMENTS

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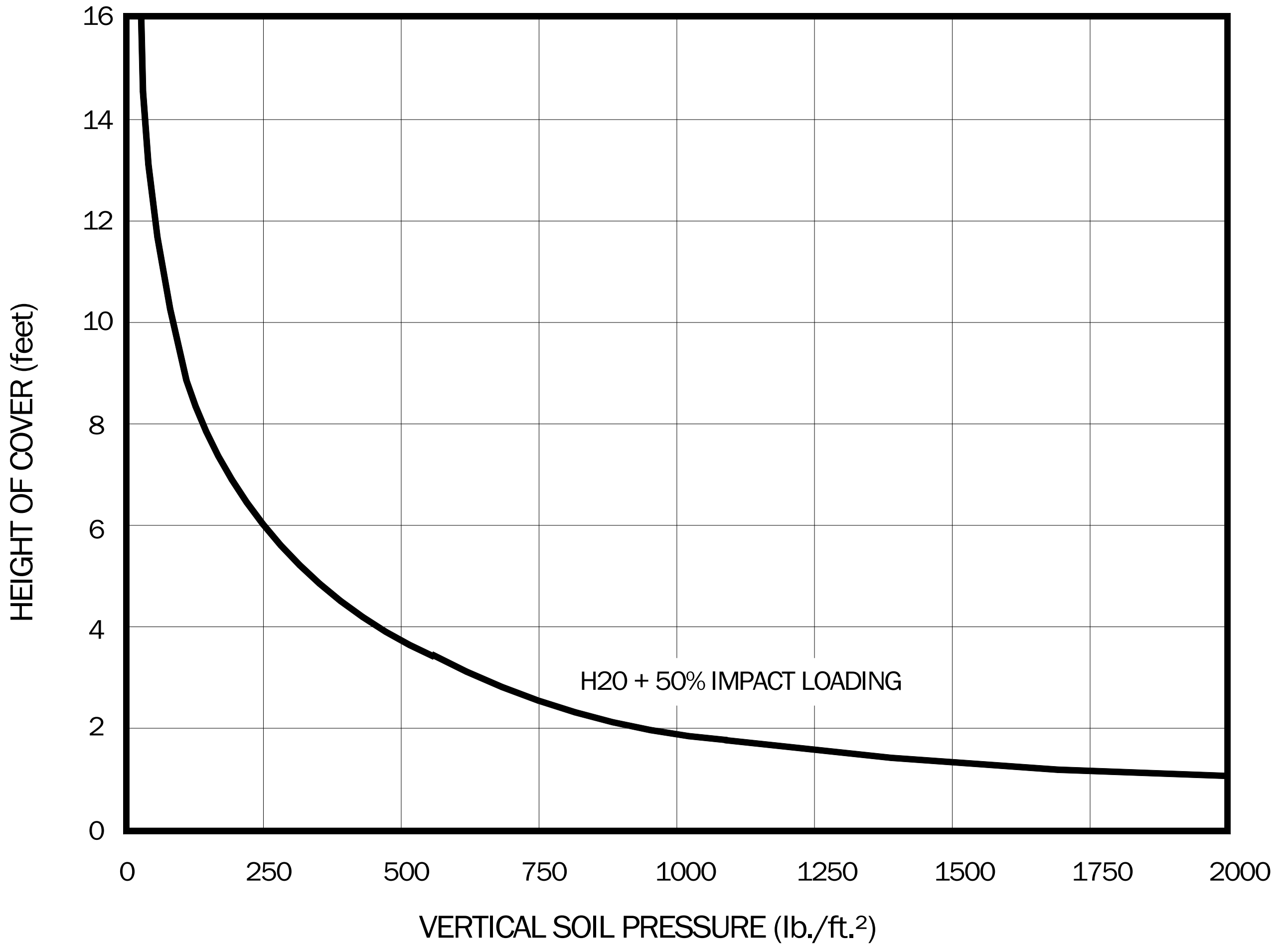
**Trench Backfill Details**

**Figure**
**12**



NOTES:

1. Apply vertical soil pressure to diameter of pipeline (horizontal projection) to calculate vertical pipe load.
2. H20 + 50% IMPACT LOADING: Simulates a highway load of a 20-ton truck with a 50% impact factor to account for the dynamic effects of the traffic.

Modified from Moser (2008)

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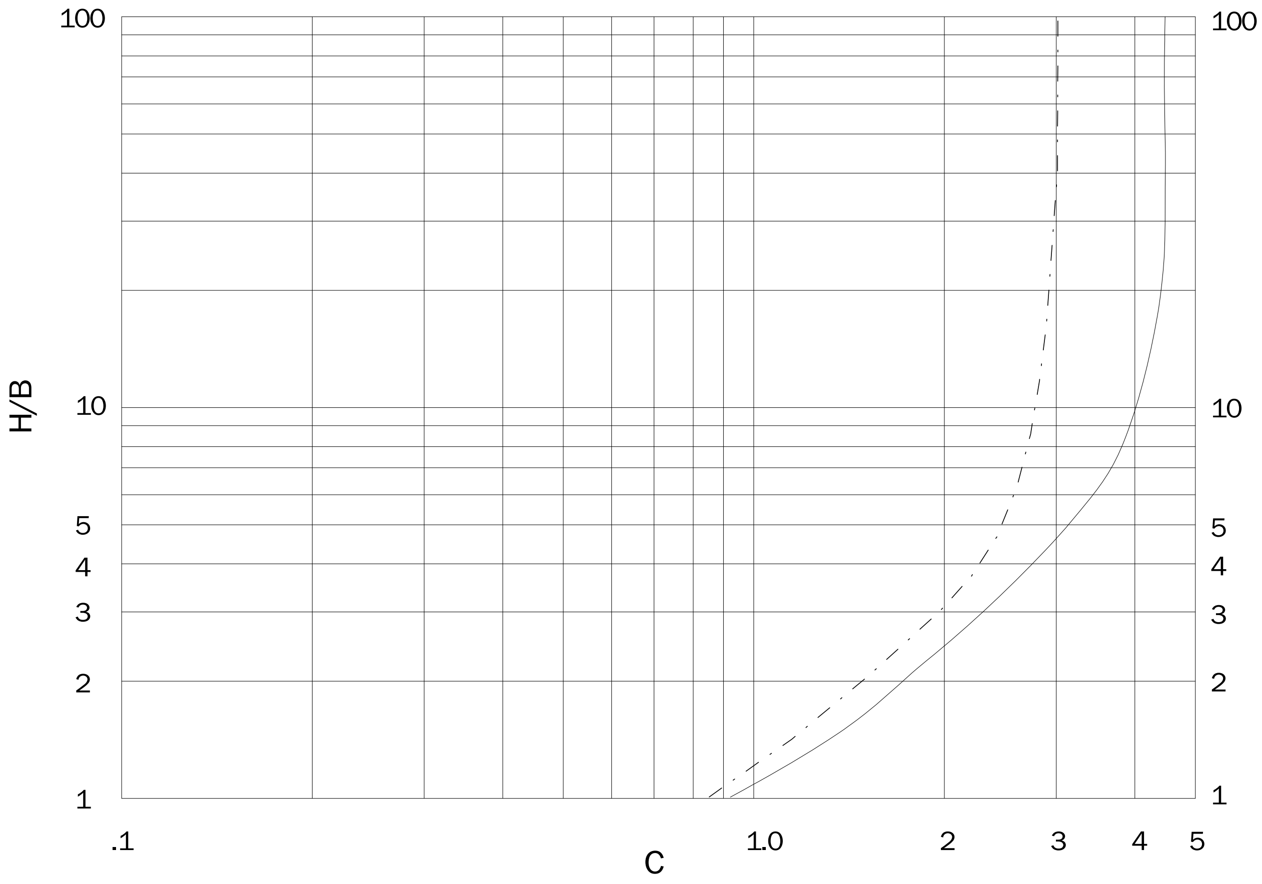
**Vertical Soil Pressure Due to Live Loads**

**Figure**

**13**



LEGEND:

— · — · — = Compacted Granular Backfill (Class 2 Aggregate Base)

——— = Excavated Fill Soil

$$W = C \gamma B^2$$

where:
W = Vertical soil load on rigid pipe due to trench backfill (pounds/foot)
$\gamma$ = Unit weight of trench backfill or overlying soil (pounds/cubic foot)
H = Depth of backfill (feet)
B = Trench width (feet)

NOTE: Marston's load coefficients are used to calculate vertical soil loads on rigid pipes installed by open-cut trenching. Refer to report text for soil loads on flexible pipes and pipes under embankment conditions (Moser, 2008).

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## Marston's Load Coefficients

**Figure**

**14**

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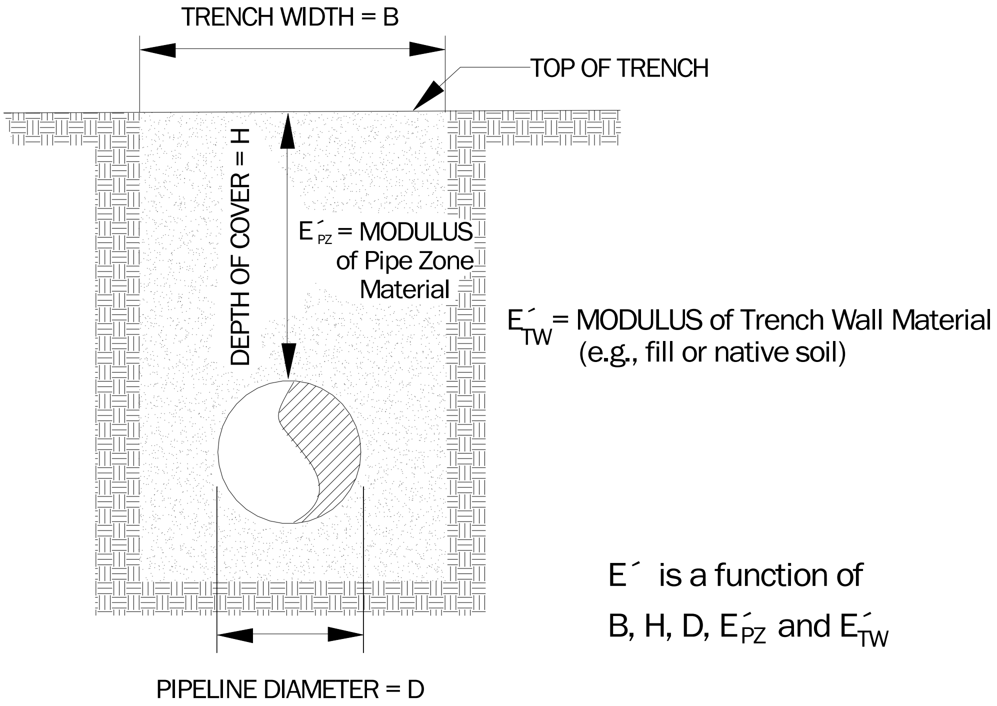

| $\frac{E'_{TW}}{E'_{PZ}}$ | $S_C$ for various B:D ratios | | | | | |
|---|---|---|---|---|---|---|
| | **1.5** | **2.0** | **2.5** | **3.0** | **4.0** | **5.0** |
| **0.1** | 0.15 | 0.30 | 0.60 | 0.80 | 0.90 | 1.00 |
| **0.2** | 0.30 | 0.45 | 0.70 | 0.85 | 0.92 | 1.00 |
| **0.4** | 0.50 | 0.60 | 0.80 | 0.90 | 0.95 | 1.00 |
| **0.6** | 0.70 | 0.80 | 0.90 | 0.95 | 1.00 | 1.00 |
| **0.8** | 0.85 | 0.90 | 0.95 | 0.98 | 1.00 | 1.00 |
| **1.0** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **1.5** | 1.30 | 1.15 | 1.10 | 1.05 | 1.00 | 1.00 |
| **2.0** | 1.50 | 1.30 | 1.15 | 1.10 | 1.05 | 1.00 |
| **3.0** | 1.75 | 1.45 | 1.30 | 1.20 | 1.08 | 1.00 |
| **$\geqslant$ 5.0** | 2.00 | 1.60 | 1.40 | 1.25 | 1.10 | 1.00 |

Modified from Jeyapalan (2001)

$$E'_C = S_C \cdot E'_{PZ}$$

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## Composite Modulus of Soil Reaction - $E'_C$

**Figure**

**15**

# Appendix A

# KEY TO BORING LOGS

| | |
|---|---|
| ☒ | Grab sample |
| ◪ | 1.4" I.D./2" O.D. Standard Penetration Test (ASTM D1586) sampler (SPT) |
| ■ | 2.5" I.D./3" O.D. Modified California sampler (MCS) with brass liners |

| RELATIVE DENSITY | | CONSISTENCY | | |
|---|---|---|---|---|
| SANDS AND GRAVELS | SPT, N | SILTS AND CLAYS | SPT, N | UNCONFINED COMPRESSIVE STRENGTH, tsf |
| VERY LOOSE | 0-4 | VERY SOFT | 0-2 | 0-0.25 |
| LOOSE | 4-10 | SOFT | 2-4 | 0.25-0.50 |
| MEDIUM DENSE | 10-30 | MEDIUM STIFF | 4-8 | 0.50-1.00 |
| DENSE | 30-50 | STIFF | 8-15 | 1.00-2.00 |
| VERY DENSE | 50+ | VERY STIFF | 15-30 | 2.00-4.00 |
| | | HARD | 30+ | >4.00 |

Reference: Terzaghi, K. and Peck, R., SOIL MECHANICS IN ENGINEERING PRACTICE, 2nd ed., John Wiley and Sons, New York, 1967. Page 341 Table 45.1 and page 347 Table 45.2.

## MOISTURE CONDITION

| DESCRIPTION | CRITERIA |
|---|---|
| DRY | Absence of moisture, dusty, dry to the touch |
| MOIST | Damp but no visible water |
| WET | Visible free water, usually soil is below water table |

Reference: ASTM D2488, Table 3 - Criteria for Describing Moisture Condition

## CONSTITUENT DESCRIPTIONS

| DESCRIPTION | CRITERIA |
|---|---|
| TRACE | less than 5% |
| FEW | 5% to 10% |
| LITTLE | 15% to 25% |
| SOME | 30% to 45% |
| MOSTLY | 50% to 100% |

Reference: ASTM D2488, Note 15

## NOTES:

1. Lines separating strata in the logs represent approximate boundaries only and are dashed where strata change depth is less certain and queried where strata change depth is not known. Actual strata change may be gradual. No warranty is provided as to the continuity of strata between borings. Logs represent the subsurface section observed at the boring location on the date of drilling only.
2. Penetration resistance (blows/ft.) are the last 12" of an 18" drive or the middle 12" of a 24" drive using a 140-pound hammer falling 30 inches per blow (Mobile B-24 rig) unless noted otherwise. The penetration resistance values noted on the logs are actual blows per foot of penetration for the respective sampler type (i.e., MCS sampler penetration resistance has not been reduced to an equivalent SPT "N" value).
3. Where noted on the boring logs, slough is defined as material from the bore hole walls which collapses or flows into and partially fills the bore hole on removal of the solid stem augers. The presence of slough within the bore hole can render drive sampling impossible (samplers fill entirely with slough) and invalidate the blow count.

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**Boring Log Legend**

Figure
**A-1**
(1 of 2)

# UNIFIED SOIL CLASSIFICATION SYSTEM

| CRITERIA FOR ASSIGNING GROUP SYMBOLS AND GROUP NAMES [A] | | | | GROUP SYMBOL | GROUP NAME [B] |
|---|---|---|---|---|---|
| **COARSE-GRAINED SOILS**<br>More than 50% retained on No. 200 sieve | **GRAVELS**<br>More than 50% of coarse fraction retained on No. 4 sieve | **Clean Gravels**<br>< 5% fines [C] | $Cu \geq 4$ and $1 \leq Cc \leq 3$ [E] | **GW** | Well-graded gravel [F] |
| | | | $Cu < 4$ and/or $1 > Cc > 3$ [E] | **GP** | Poorly graded gravel [F] |
| | | **Gravels with Fines**<br>> 12% fines [C] | Fines classify as ML or MH | **GM** | Silty gravel [F,G,H] |
| | | | Fines classify as CL or CH | **GC** | Clayey gravel [F,G,H] |
| | **SANDS**<br>50% or more of coarse fraction passes No. 4 sieve | **Clean Sands**<br>< 5% fines [D] | $Cu \geq 6$ and $1 \leq Cc \leq 3$ [E] | **SW** | Well-graded sand [I] |
| | | | $Cu < 6$ and/or $1 > Cc > 3$ [E] | **SP** | Poorly graded sand [I] |
| | | **Sands with Fines**<br>> 12% fines [D] | Fines classify as ML or MH | **SM** | Silty sand [G,H,I] |
| | | | Fines classify as CL or CH | **SC** | Clayey sand [G,H,I] |
| **FINE-GRAINED SOILS**<br>50% or more passes the No. 200 sieve | **SILTS AND CLAYS**<br>Liquid limit $\leq 50$ | **Inorganic** | PI > 7 plots on or above "A" line [J] | **CL** | Lean clay [K,L,M] |
| | | | PI < 4 plots below "A" line [J] | **ML** | Silt [K,L,M] |
| | | **Organic** | $\frac{\text{Liquid limit-oven dried}}{\text{Liquid limit-not dried}} < 0.75$ | **OL** | Organic Clay [K,L,M,N] |
| | | | | | Organic Silt [K,L,M,O] |
| | **SILTS AND CLAYS**<br>Liquid limit > 50 | **Inorganic** | PI plots on or above "A" line | **CH** | Fat clay [K,L,M] |
| | | | PI plots below "A" line | **MH** | Elastic silt [K,L,M] |
| | | **Organic** | $\frac{\text{Liquid limit-oven dried}}{\text{Liquid limit-not dried}} < 0.75$ | **OH** | Organic Clay [K,L,M,P] |
| | | | | | Organic Silt [K,L,M,Q] |
| **HIGHLY ORGANIC SOILS** | | **Primarily organic matter, dark color and organic odor** | | **PT** | Peat |

**NOTES:**

**A** Based on the material passing the 3-in. (75mm) sieve.

**B** If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

**C** Gravels with 5% to 12% fines require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay

**D** Sands with 5% to 12% fines require dual symbols:
SW-SM well-graded sand with silt
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay

**E** $Cu = \frac{D_{60}}{D_{10}}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

**F** If soil contains $\geq$ 15% sand, add "with sand" to group name.

**G** If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

**H** If fines are organic, add "with organic fines" to group name.

**I** If soil contains $\geq$ 15% gravel, add "with gravel" to group name.

**J** If Atterberg limits plot in hatched area, soil is a CL-ML (silty clay).

**K** If soil contains 15% to 29% plus No. 200, add "with sand" or "with gravel", whichever is predominant.

**L** If soil contains $\geq$ 30% plus No.200, predominantly sand, add "sandy" to group name.

**M** If soil contains $\geq$ 30% plus No.200, predominantly gravel, add "gravelly" to group name.

**N** PI $\geq$ 4 and plots on or above "A" line.

**O** PI < 4 or plots below "A" line.

**P** PI plots on or above "A" line.

**Q** PI plots below "A" line.

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City of Pittsburg
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Pittsburg, California
**Boring Log Legend**

Figure
**A-1**
(2 of 2)

# Appendix B

## LOG OF BORING B-1①

**LOCATION:** Sludge Pump East Side of Sed. Basin (see Figure 2).

**GROUND SURFACE:** Approx. El. 144'④

| DEPTH feet | SAMPLE NO. | TYPE | PENETRATION RESISTANCE blows/ft. | GROUNDWATER ③ | DESCRIPTION ② | % MOISTURE % | DRY DENSITY lbs./ft.³ | LIQUID LIMIT | PLASTICITY INDEX | GRAIN SIZE Gravel (>#4 sieve) % | GRAIN SIZE Sand (#4 to #200 sieve) % | GRAIN SIZE Fines (<#200 sieve) % | UNCONFINED COMPRESSIVE STRENGTH kips/ft.² | DIRECT SHEAR Cohesion p.s.f. | DIRECT SHEAR Internal Friction Angle |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | ■ | 44 | | **SANDY LEAN CLAY (CL) - FILL**<br>- dark olive brown/grayish brown<br>- fine to coarse sand<br>- few fine gravel<br>- very stiff<br>- dry | 14 | 113 | | | | | | 12.3 | | |
| 5 | 2 | ◤ | 23 | | | | | | | | | | | | |
| | 3 | ■ | 35 | | **CLAYEY SAND (SC)**<br>- light yellowish brown<br>- fine sand<br>- weakly cemented<br>- medium dense<br>- dry | 10 | 103 | | | | | | | | |
| 10 | 4 | ◤ | 27 | | | | | | | 0 | 53 | 47 | | | |
| 15 | 5 | ◤ | 26 | | **CLAYEY SAND (SC) to POORLY-GRADED SAND WITH SILT (SP-SM)**<br>- pale yellow<br>- trace coarse angular gravel/rock (~1.5")<br>- medium dense<br>- dry | | | | | | | | | | |
| 20 | 6 | ◤ | 27 | | **POORLY-GRADED SAND WITH SILT (SP-SM)**<br>- pale brown<br>- trace to few gravel/ cemented nodules<br>- medium dense to dense<br>- dry<br>Borehole sloughing below 17 ½' (see table below) | 4 | | | | 4 | 89 | 7 | | | |
| 25 | 7 | ◤ | 33 | | **LEAN CLAY (CL)**<br>- yellowish brown<br>- trace sand<br>- very stiff to hard<br>- moist | 3 | | | | | | | | | |

**BOTTOM OF BORING AT 25 FEET**

SLOUGH DEPTHS ON SAMPLING

| Sample No. | Slough Depth* |
|---|---|
| 1-6 | 17 ½' |
| 1-7 | 21 |

*- slough depth measured from intended sample depth

NOTES
① Drilled 03/13/13 using a Mobile B-24, 5" diameter solid stem augers, and a 30" drop by 140 lb. cathead sampling hammer.
② See report text and figures in Appendices A and C for definitions, lab test results, and additional soil descriptions.
③ Free groundwater level not encountered during or after drilling. Static equilibrium groundwater depth is unknown.
④ Surface elevation approximated from plans provided by Brown and Caldwell (4/22/13).

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Pittsburg, California

**Log of Boring B-1**

Figure
**B-1**

# LOG OF BORING B-2①

LOCATION: Near NE Corner of Sed Basins (see Figure 2).

GROUND SURFACE: Approx. El. 144'④

| DEPTH feet | SAMPLE NO. | TYPE | PENETRATION RESISTANCE blows/ft. | GROUNDWATER ③ | DESCRIPTION ② | MOISTURE % | DRY DENSITY lbs./ft.³ | LIQUID LIMIT | PLASTICITY INDEX | GRAIN SIZE Gravel (>#4 sieve) % | GRAIN SIZE Sand (#4 to #200 sieve) % | GRAIN SIZE Fines (<#200 sieve) % | UNCONFINED COMPRESSIVE STRENGTH kips/ft.² | DIRECT SHEAR Cohesion p.s.f. | DIRECT SHEAR Internal Friction Angle |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | ⊠ | | | **LEAN/FAT CLAY WITH SAND (CL/CH) - FILL**<br>- dark yellowish brown to dark brown<br>- fine to coarse sand<br>- trace fine gravel<br>- very stiff<br>- dry | 13 | | 50 | 31 | | | | | | |
| 5 | 2 | ■ | 27 | | **LEAN/FAT CLAY (CL/CH) - FILL**<br>- dark grayish brown<br>- few sand<br>- pieces of concrete @ 7'<br>- very stiff<br>- dry/moist | 13 | 105 | | | | | | | | |
| | 3 | ◣ | 19 | | | 14 | | | | | | | | | |
| | | | | | **BOTTOM OF BORING AT 7 FEET** | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | | | |

NOTES

① Drilled 03/13/13 using a Mobile B-24, 5" diameter solid stem augers, and a 30" drop by 140 lb. cathead sampling hammer.
② See report text and figures in Appendices A and C for definitions, lab test results, and additional soil descriptions.
③ Free groundwater level not encountered during or after drilling. Static equilibrium groundwater depth is unknown.
④ Surface elevation approximated from plans provided by Brown and Caldwell (4/22/13).

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**Log of Boring B-2**

Figure
**B-2**

## LOG OF BORING B-3 ①

LOCATION: Near SE corner of Sed Basins (see Figure 2).

GROUND SURFACE: Approx. El. 149' ④

| DEPTH feet | SAMPLE NO. | TYPE | PENETRATION RESISTANCE blows/ft. | GROUNDWATER ③ | DESCRIPTION ② | % MOISTURE % | DRY DENSITY lbs./ft.³ | LIQUID LIMIT | PLASTICITY INDEX | GRAIN SIZE Gravel (>#4 sieve) % | GRAIN SIZE Sand (#4 to #200 sieve) % | GRAIN SIZE Fines (<#200 sieve) % | UNCONFINED COMPRESSIVE STRENGTH kips/ft.² | DIRECT SHEAR Cohesion p.s.f. | DIRECT SHEAR Internal Friction Angle |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | 1 | ☒ |  |  | **CLAYEY SAND (SC) - POSSIBLE FILL**<br>- dark yellowish brown to olive brown<br>- sandier with depth<br>- dense to medium dense<br>- dry to moist | 20 |  |  |  | 1 | 55 | 44 |  |  |  |
| 5 | 2 | ■ | 52 |  |  | 17 | 99 |  |  |  |  |  |  |  |  |
|  | 3 | ◣ | 13 |  |  | 15 |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | **BOTTOM OF BORING AT 7 FEET** |  |  |  |  |  |  |  |  |  |  |
| 10 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 15 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 20 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 25 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

NOTES

① Drilled 03/13/13 using a Mobile B-24, 5" diameter solid stem augers, and a 30" drop by 140 lb. cathead sampling hammer.
② See report text and figures in Appendices A and C for definitions, lab test results, and additional soil descriptions.
③ Free groundwater level not encountered during or after drilling. Static equilibrium groundwater depth is unknown.
④ Surface elevation approximated from plans provided by Brown and Caldwell (4/22/13).

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**Log of Boring B-3**

Figure
**B-3**

## LOG OF BORING B-4 ①

**LOCATION:** Planned Sludge Thickener Tank (see Figure 2).

**GROUND SURFACE:** Approx. El. 156' ④

| DEPTH feet | SAMPLE NO. | TYPE | PENETRATION RESISTANCE blows/ft. | GROUNDWATER ③ | **DESCRIPTION** ② | % MOISTURE % | DRY DENSITY lbs./ft.³ | LIQUID LIMIT | PLASTICITY INDEX | GRAIN SIZE | | | UNCONFINED COMPRESSIVE STRENGTH kips/ft.² | DIRECT SHEAR | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Gravel (>#4 sieve) % | Sand (#4 to #200 sieve) % | Fines (<#200 sieve) % | | Cohesion p.s.f. | Internal Friction Angle |
| | 1 | ■ | 24 | | **FAT CLAY WITH SAND (CH)**<br>- very dark gray<br>- fine to coarse sand (sandier with depth)<br>- stiff/very stiff<br>- dry/moist | 17 | 109 | 52 | 31 | | | | 14.0 | | |
| | 2 | ◤ | 17 | | | | | | | | | | | | |
| 5 | | | | | **SANDY LEAN CLAY (CL)**<br>- brownish yellow<br>- very stiff to hard<br>- dry | | | | | | | | | | |
| | 3 | ■ | 67 | | | 14 | 106 | | | | | | | | |
| | 4 | ◤ | 33 | | | | | | | 0 | 42 | 58 | | | |
| 10 | | | | | | | | | | | | | | | |
| | | | | | **CLAYEY SAND (SC)**<br>- brownish yellow<br>- fine sand<br>- weakly cemented<br>- medium dense<br>- dry | | | | | | | | | | |
| | 5 | ◤ | 23 | | | 14 | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | |
| | | | | | - gravelly at 17 ½' (per driller) | | | | | | | | | | |
| | 6 | ◤ | 25 | | | 16 | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | |
| | 7 | ◤ | 25 | | | | | | | | | | | | |
| 25 | | | | | **BOTTOM OF BORING AT 25 FEET** | | | | | | | | | | |

NOTES
① Drilled 03/13/13 using a Mobile B-24, 5" diameter solid stem augers, and a 30" drop by 140 lb. cathead sampling hammer.
② See report text and figures in Appendices A and C for definitions, lab test results, and additional soil descriptions.
③ Free groundwater level not encountered during or after drilling. Static equilibrium groundwater depth is unknown.
④ Surface elevation approximated from plans provided by Brown and Caldwell (4/22/13).

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**Log of Boring B-4**

Figure
**B-4**

## LOG OF BORING B-5 ①

**LOCATION:** 70 feet south of SW corner of Sed Basins (see Figure 2).

**GROUND SURFACE:** Approx. El. 157' ④

| DEPTH feet | SAMPLE NO. | TYPE | PENETRATION RESISTANCE blows/ft. | GROUNDWATER ③ | DESCRIPTION ② | % MOISTURE % | DRY DENSITY lbs./ft.³ | LIQUID LIMIT | PLASTICITY INDEX | GRAIN SIZE Gravel (>#4 sieve) % | GRAIN SIZE Sand (#4 to #200 sieve) % | GRAIN SIZE Fines (<#200 sieve) % | UNCONFINED COMPRESSIVE STRENGTH kips/ft.² | DIRECT SHEAR Cohesion p.s.f. | DIRECT SHEAR Internal Friction Angle |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | ■ | 27 | | **LEAN CLAY WITH SAND (CL)**<br>- dark brown<br>- fine to coarse sand (sandier with depth)<br>- very stiff<br>- dry/moist | 16 | 108 | 48 | 30 | | | | | | |
| 5 | 2 | ◤ | 19 | | **SANDY LEAN CLAY (CL)**<br>- dark reddish brown<br>- very stiff/medium dense<br>- dry to moist<br>- trace caliche | 15 | | | | 0 | 31 | 69 | | | |
| 10 | 3 | ◤ | 22 | | **SILTY SAND (SM)**<br>- yellowish brown<br>- weakly cemented<br>- medium dense<br>- dry to moist | 12 | | | | 1 | 64 | 35 | FINES<br>27% Silt<br>8% Clay | | |
| 15 | 4 | ◤ | 26 | | - trace to few caliche | 21 | | | | | | | | | |
| 20 | 5 | ◤ | 36 | | **CLAYEY SAND WITH GRAVEL (SC)**<br>- pale yellowish brown<br>- fine sand<br>- fine rounded and angular gravel<br>- weakly cemented<br>- dense<br>- dry | 10 | | | | | | | | | |
| 25 | | | | | **BOTTOM OF BORING AT 21 FEET** | | | | | | | | | | |

**NOTE:**
Drilling became very rough around 20', and eventually hit refusal at 21'. Most likely large gravels/cobbles.

NOTES
① Drilled 03/13/13 using a Mobile B-24, 5" diameter solid stem augers, and a 30" drop by 140 lb. cathead sampling hammer.
② See report text and figures in Appendices A and C for definitions, lab test results, and additional soil descriptions.
③ Free groundwater level not encountered during or after drilling. Static equilibrium groundwater depth is unknown.
④ Surface elevation approximated from plans provided by Brown and Caldwell (4/22/13).

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**Log of Boring B-5**

Figure
**B-5**

## LOG OF BORING B-6 ①

LOCATION: 15' s/o Existing Pump Station (see Figure 2).

GROUND SURFACE: Approx. El. 170' ④

| DEPTH feet | SAMPLE NO. | TYPE | PENETRATION RESISTANCE blows/ft. | GROUNDWATER ③ | DESCRIPTION ② | MOISTURE % | DRY DENSITY lbs./ft.³ | LIQUID LIMIT | PLASTICITY INDEX | GRAIN SIZE Gravel (>#4 sieve) % | GRAIN SIZE Sand (#4 to #200 sieve) % | GRAIN SIZE Fines (<#200 sieve) % | UNCONFINED COMPRESSIVE STRENGTH kips/ft.² | DIRECT SHEAR Cohesion p.s.f. | DIRECT SHEAR Internal Friction Angle |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  | **LEAN/FAT CLAY (CL/CH) - POSSIBLE FILL**<br>- very dark grayish brown<br>- few fine to coarse sand<br>- dry/moist |  |  |  |  |  |  |  |  |  |  |
|  | 1 | ☒ |  |  |  | 19 |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | **SANDY LEAN CLAY (CL)**<br>- dark grayish brown/pale brown - hard<br>- fine to coarse sand, trace gravel - dry |  |  |  |  |  |  |  |  |  |  |
| 5 | 2 | ■ | 36 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 3 | ◣ | 10/6" |  |  | 12 |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | **BOTTOM OF BORING AT 6 FEET** |  |  |  |  |  |  |  |  |  |  |
| 10 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 15 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 20 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 25 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**NOTE:**
Encountered obstruction at 6' during SPT sampling. Most likely was unmarked concrete pipe. Sampling was terminated.

NOTES
① Drilled 03/14/13 using a Mobile B-24, 5" diameter solid stem augers, and a 30" drop by 140 lb. cathead sampling hammer.
② See report text and figures in Appendices A and C for definitions, lab test results, and additional soil descriptions.
③ Free groundwater level not encountered during or after drilling. Static equilibrium groundwater depth is unknown.
④ Surface elevation approximated from plans provided by Brown and Caldwell (4/22/13).

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**Log of Boring B-6**

Figure
**B-6**

# LOG OF BORING B-7①

**LOCATION:** Between upper and lower ponds (see Figure 2).

**GROUND SURFACE:** Approx. El. 160'④

| DEPTH feet | SAMPLE NO. | TYPE | PENETRATION RESISTANCE blows/ft. | GROUNDWATER ③ | DESCRIPTION ② | % MOISTURE % | DRY DENSITY lbs./ft.³ | LIQUID LIMIT | PLASTICITY INDEX | GRAIN SIZE Gravel (>#4 sieve) % | GRAIN SIZE Sand (#4 to #200 sieve) % | GRAIN SIZE Fines (<#200 sieve) % | UNCONFINED COMPRESSIVE STRENGTH kips/ft.² | DIRECT SHEAR Cohesion p.s.f. | DIRECT SHEAR Internal Friction Angle |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | ■ | 9 | | **SANDY LEAN CLAY (CL) - FILL**<br>- dark gray and dark yellowish brown<br>- trace gravel, sandier with depth<br>- medium stiff | 21 | 100 | 47 | 25 | 2 | 36 | 62 | 3.96 | | |
| 5 | 2 | ◤ | 10 | | - gravel at 5' to 6' (per driller) | | | | | | | | | | |
| | 3 | ■ | 11 | | **LEAN CLAY WITH SAND (CL) - FILL**<br>- dark yellowish brown<br>- fine to medium sand<br>- medium stiff<br>- moist | 21 | 96 | | | | | | | 220 | 19° |
| | | | | | | 20 | 105 | 36 | 16 | | | | 1.92 | | |
| 10 | 4 | ◤ | 7 | | | | | | | | | | | | |
| 15 | 5 | ■ | 10 | | - dark gray mottling<br>- very moist | 22 | 106 | | | | | | 1.19 | | |
| 20 | 6 | ◤ | 6 | | **LEAN CLAY WITH SAND (CL)**<br>- very dark gray<br>- fine to coarse sand, trace gravel<br>- medium stiff<br>- very moist | 27 | | | | | | | | | |
| | | | | | **BOTTOM OF BORING AT 20 FEET** | | | | | | | | | | |
| 25 | | | | | | | | | | | | | | | |

NOTES

① Drilled 03/14/13 using a Mobile B-24, 5" diameter solid stem augers, and a 30" drop by 140 lb. cathead sampling hammer.
② See report text and figures in Appendices A and C for definitions, lab test results, and additional soil descriptions.
③ Free groundwater level not encountered during or after drilling. Static equilibrium groundwater depth is unknown.
④ Surface elevation approximated from plans provided by Brown and Caldwell (4/22/13).

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**Log of Boring B-7**

Figure
**B-7**

## LOG OF BORING B-8 ①

LOCATION: 40' n/o Planned Sludge Forcemain, Sta. 2+10 (see Figure 2).

GROUND SURFACE: Approx. El. 149' ④

| DEPTH feet | SAMPLE NO. | TYPE | PENETRATION RESISTANCE blows/ft. | GROUNDWATER ③ | DESCRIPTION ② | MOISTURE % | DRY DENSITY lbs./ft.$^3$ | LIQUID LIMIT | PLASTICITY INDEX | GRAIN SIZE Gravel (>#4 sieve) % | GRAIN SIZE Sand (#4 to #200 sieve) % | GRAIN SIZE Fines (<#200 sieve) % | UNCONFINED COMPRESSIVE STRENGTH kips/ft.$^2$ | DIRECT SHEAR Cohesion p.s.f. | DIRECT SHEAR Internal Friction Angle |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | 1 | ☒ |  |  | **LEAN/FAT CLAY (CL/CH)**<br>- very dark grayish brown<br>- few sand<br>- stiff/very stiff<br>- dry/moist<br>- few caliche | 20 |  |  |  |  |  |  |  |  |  |
| 5 | 2 | ■ | 21 |  |  | 20 | 105 |  |  |  |  |  |  |  |  |
|  | 3 | ◣ | 15 |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | **BOTTOM OF BORING AT 7 FEET** |  |  |  |  |  |  |  |  |  |  |
| 10 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 15 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 20 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 25 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

NOTES

① Drilled 03/13/13 using a Mobile B-24, 5" diameter solid stem augers, and a 30" drop by 140 lb. cathead sampling hammer.
② See report text and figures in Appendices A and C for definitions, lab test results, and additional soil descriptions.
③ Free groundwater level not encountered during or after drilling. Static equilibrium groundwater depth is unknown.
④ Surface elevation approximated from plans provided by Brown and Caldwell (4/22/13).

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**Log of Boring B-8**

Figure
**B-8**

# LOG OF BORING B-9 ①

LOCATION: 20' n/e corner of Lower Pond (see Figure 2).

GROUND SURFACE: Approx. El. 139' ④

| DEPTH feet | SAMPLE NO. | TYPE | PENETRATION RESISTANCE blows/ft. | GROUNDWATER ③ | DESCRIPTION ② | % MOISTURE % | DRY DENSITY lbs./ft.$^3$ | LIQUID LIMIT | PLASTICITY INDEX | GRAIN SIZE Gravel (>#4 sieve) % | GRAIN SIZE Sand (#4 to #200 sieve) % | GRAIN SIZE Fines (<#200 sieve) % | UNCONFINED COMPRESSIVE STRENGTH kips/ft.$^2$ | DIRECT SHEAR Cohesion p.s.f. | DIRECT SHEAR Internal Friction Angle |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | 1 | ■ | 11 |  | **LEAN/FAT CLAY WITH SAND (CL/CH) - FILL**<br>- dark brown/brown/pale brown<br>- fine to coarse sand, few gravel<br>- medium stiff<br>- dry/moist | 14 | 97 |  |  |  |  |  |  |  |  |
| 5 | 2 | ◤ | 6 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 3 | ■ | 18 |  | **FAT CLAY (CH)**<br>- very dark grayish brown<br>- trace to few fine sand (sandier with depth)<br>- trace rounded gravel<br>- stiff<br>- moist | 24<br>23 | 100<br>102 | 56 | 34 |  |  |  | 4.07 |  |  |
| 10 | 4 | ◤ | 12 |  |  |  |  |  |  |  |  |  |  |  |  |
| 15 | 5 | ◤ | 26 |  | **CLAYEY SAND (SC)**<br>- yellowish brown<br>- weakly cemented<br>- medium dense<br>- dry |  |  |  |  | 1 | 51 | 48 |  |  |  |
| 20 | 6 | ◤ | 25 |  |  | 13 |  |  |  |  |  |  |  |  |  |
| 25 | 7 | ◤ | 38 |  | **CLAYEY SAND (SC)**<br>- yellowish/grayish brown<br>- fine to coarse sand<br>- few fine gravel<br>- dense<br>- dry/moist | 9 |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | **BOTTOM OF BORING AT 25 FEET** |  |  |  |  |  |  |  |  |  |  |

NOTES

① Drilled 03/13/13 using a Mobile B-24, 5" diameter solid stem augers, and a 30" drop by 140 lb. cathead sampling hammer.
② See report text and figures in Appendices A and C for definitions, lab test results, and additional soil descriptions.
③ Free groundwater level not encountered during or after drilling. Static equilibrium groundwater depth is unknown.
④ Surface elevation approximated from plans provided by Brown and Caldwell (4/22/13).

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Pittsburg, California

**Log of Boring B-9**

Figure
**B-9**

## LOG OF BORING B-10①

**LOCATION:** 12' w/o curb and 20' n/o curb in grassy area (see Figure 2).

**GROUND SURFACE:** Approx. El. 143'④

| DEPTH feet | SAMPLE NO. | TYPE | PENETRATION RESISTANCE blows/ft. | GROUNDWATER ③ | DESCRIPTION ② | MOISTURE % | DRY DENSITY lbs./ft.³ | LIQUID LIMIT | PLASTICITY INDEX | GRAIN SIZE |  |  | UNCONFINED COMPRESSIVE STRENGTH kips/ft.² | DIRECT SHEAR |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |  |  | Gravel (>#4 sieve) % | Sand (#4 to #200 sieve) % | Fines (<#200 sieve) % |  | Cohesion p.s.f. | Internal Friction Angle |
|  | 1 | ■ | 41 |  | **SANDY LEAN CLAY (CL) - FILL**<br>- dark brown/brown<br>- fine to coarse sand<br>- trace organics (plant roots)<br>- hard<br>- moist/dry | 13 | 110 | 42 | 22 |  |  |  | 10.2 |  |  |
| 5 | 2 | ◤ | 29 |  | **SANDY LEAN CLAY/SILT (CL/ML) to SILTY SAND (SM)**<br>- light brown and white<br>- mostly fine sand<br>- very stiff/medium dense<br>- weakly cemented<br>- dry |  |  |  |  |  |  |  |  |  |  |
| 10 | 3 | ◤ | 34 |  | - hard/dense | 16 |  |  |  |  |  |  |  |  |  |
|  | 4 | ◤ | 30 |  |  | 19 |  | 34 | 10 |  |  |  |  |  |  |
| 15 |  |  |  |  | **SILTY/CLAYEY SAND (SM/SC)**<br>- yellowish brown<br>- fine sand<br>- hard to very stiff<br>- dry |  |  |  |  |  |  |  |  |  |  |
| 20 | 5 | ◤ | 22 |  |  | 20 |  |  |  |  |  |  |  |  |  |
|  | 6 | ◤ | 31 |  | **SILTY SAND (SM)**<br>- light brown/grayish brown<br>- fine to medium sand<br>- dense<br>- weakly cemented<br>- dry | 9 |  |  |  |  |  |  |  |  |  |
| 25 |  |  |  |  | **BOTTOM OF BORING AT 25 FEET** |  |  |  |  |  |  |  |  |  |  |

**NOTE:**
Gravels/cobbles encountered during drilling from 4' to 7'. Very difficult to drill through, instead broke through with SPT sample barrel.

NOTES
① Drilled 03/14/13 using a Mobile B-24, 5" diameter solid stem augers, and a 30" drop by 140 lb. cathead sampling hammer.
② See report text and figures in Appendices A and C for definitions, lab test results, and additional soil descriptions.
③ Free groundwater level not encountered during or after drilling. Static equilibrium groundwater depth is unknown.
④ Surface elevation approximated from plans provided by Brown and Caldwell (4/22/13).

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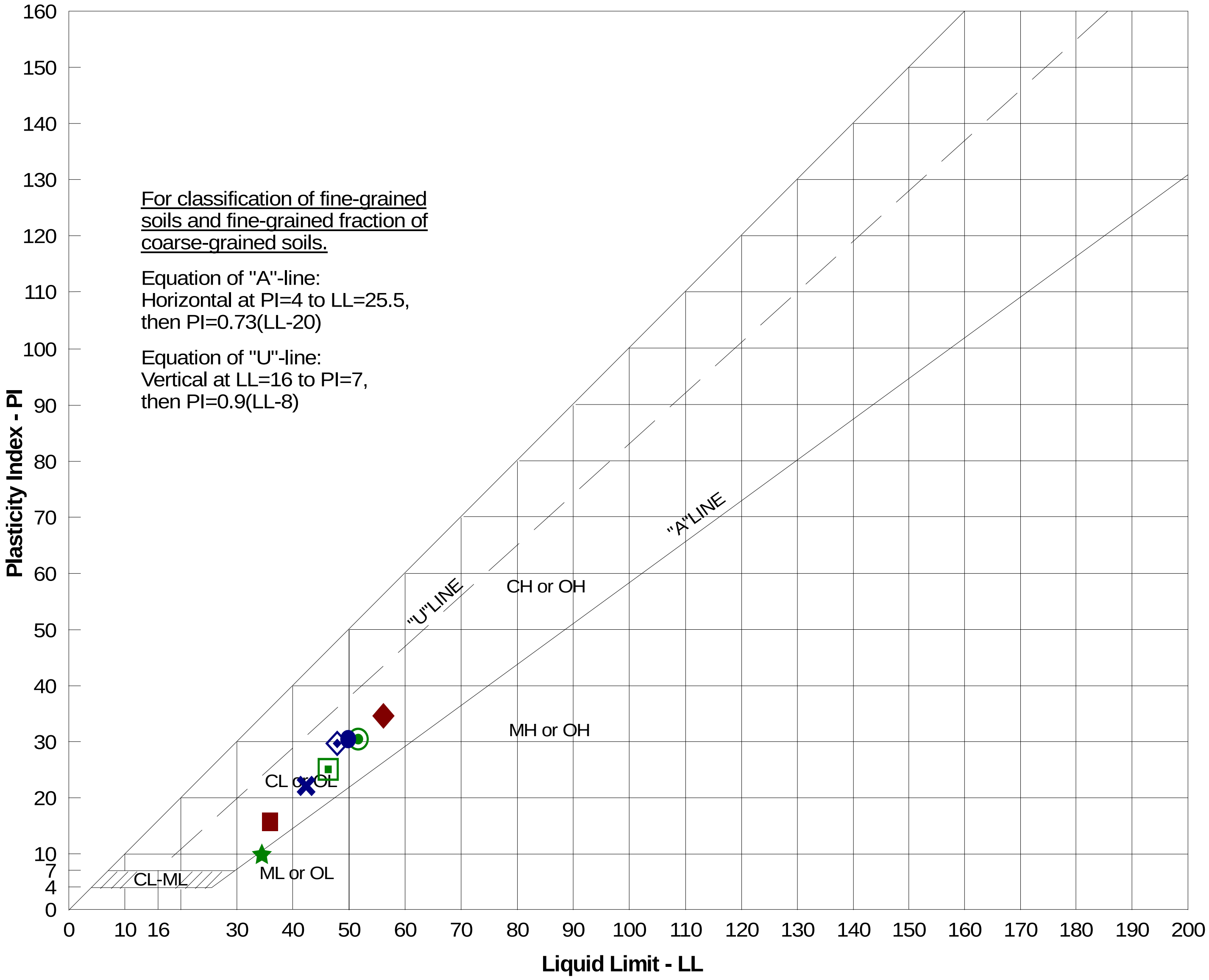
**Log of Boring B-10**

Figure
**B-10**

# Appendix C



| TEST SYMBOL | SAMPLE NO. | DEPTH (ft) | LIQUID LIMIT - LL | PLASTICITY INDEX - PI | GROUP SYMBOL* |
|---|---|---|---|---|---|
| ● | B-2-1 | 1-3 | 50 | 31 | CH |
| ◉ | B-4-1 | 3-3½ | 52 | 31 | CH |
| ◈ | B-5-1 | 2½-3 | 48 | 30 | CL |
| ▣ | B-7-1 | 3-3½ | 47 | 25 | CL |
| ■ | B-7-3 | 8-8½ | 36 | 16 | CL |
| ◆ | B-9-3 | 7½-8 | 56 | 34 | CH |
| ✖ | B-10-1 | 3-3½ | 42 | 22 | CL |
| ★ | B-10-4 | 13½-15 | 34 | 10 | ML |

* Classification of fines < 0.425mm

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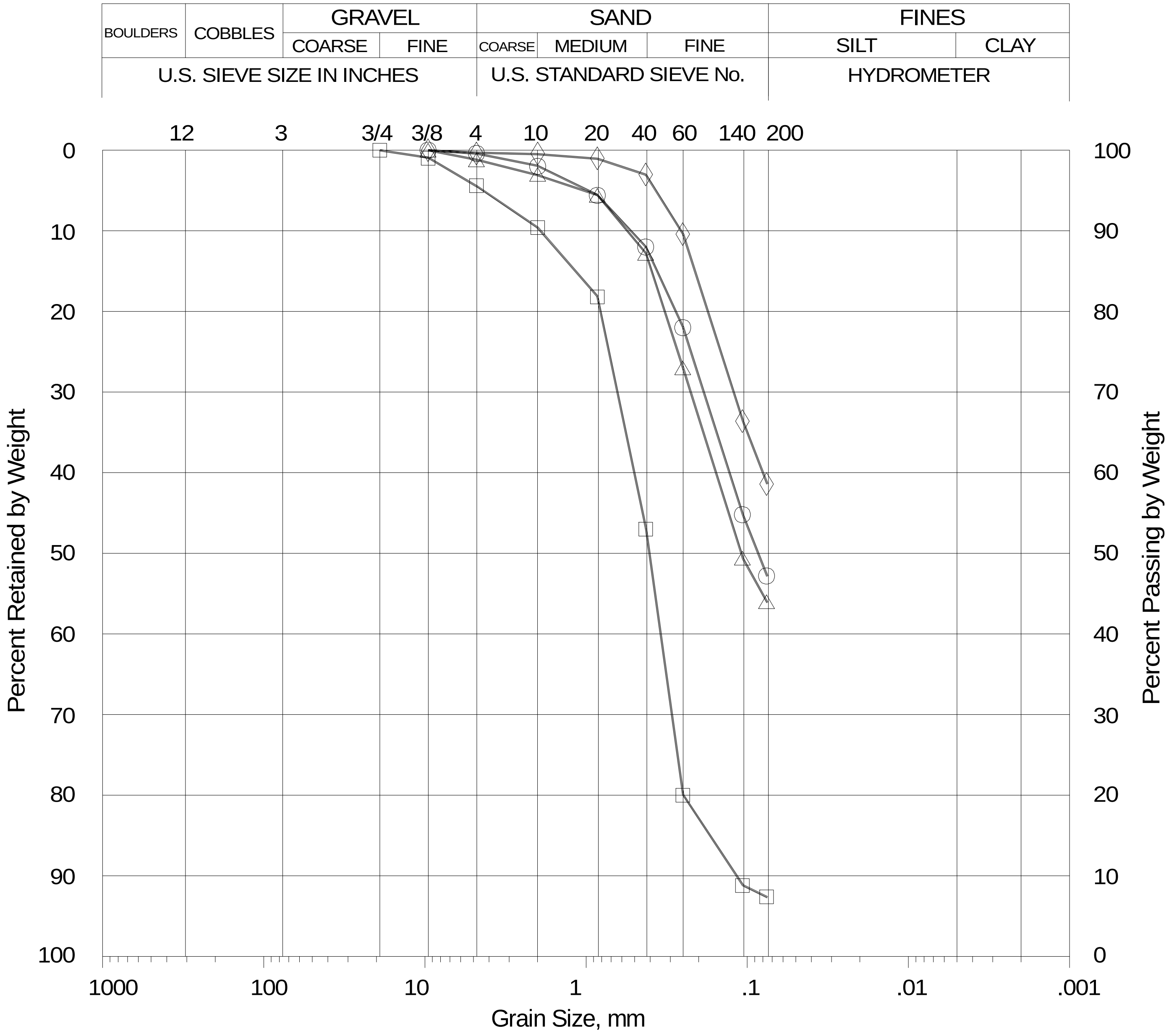
## Plasticity Index

**Figure**

**C-1**



| TEST SYMBOL | BORING SAMPLE NO. | DEPTH (ft) | GROUP SYMBOL | DESCRIPTION (based on grain size) |
|---|---|---|---|---|
| ○ | B-1-4 | 8½-10 | SC | clayey sand |
| □ | B-1-6 | 18½-20 | SP-SM | poorly graded sand with silt |
| △ | B-3-1 | 1-3 | SC | clayey sand |
| ◇ | B-4-4 | 8½-10 | CL | sandy lean clay |

**NOTE:** The largest particle (grain) size that could have been sampled from our borings by our sample barrels is a function of the inside diameter of the sample barrels used (see Figure A-1). Therefore, there may be larger particles (e.g., coarse gravel, cobbles or boulders) in the soils sampled than reflected on the boring logs and grain size distribution curves provided in this report.

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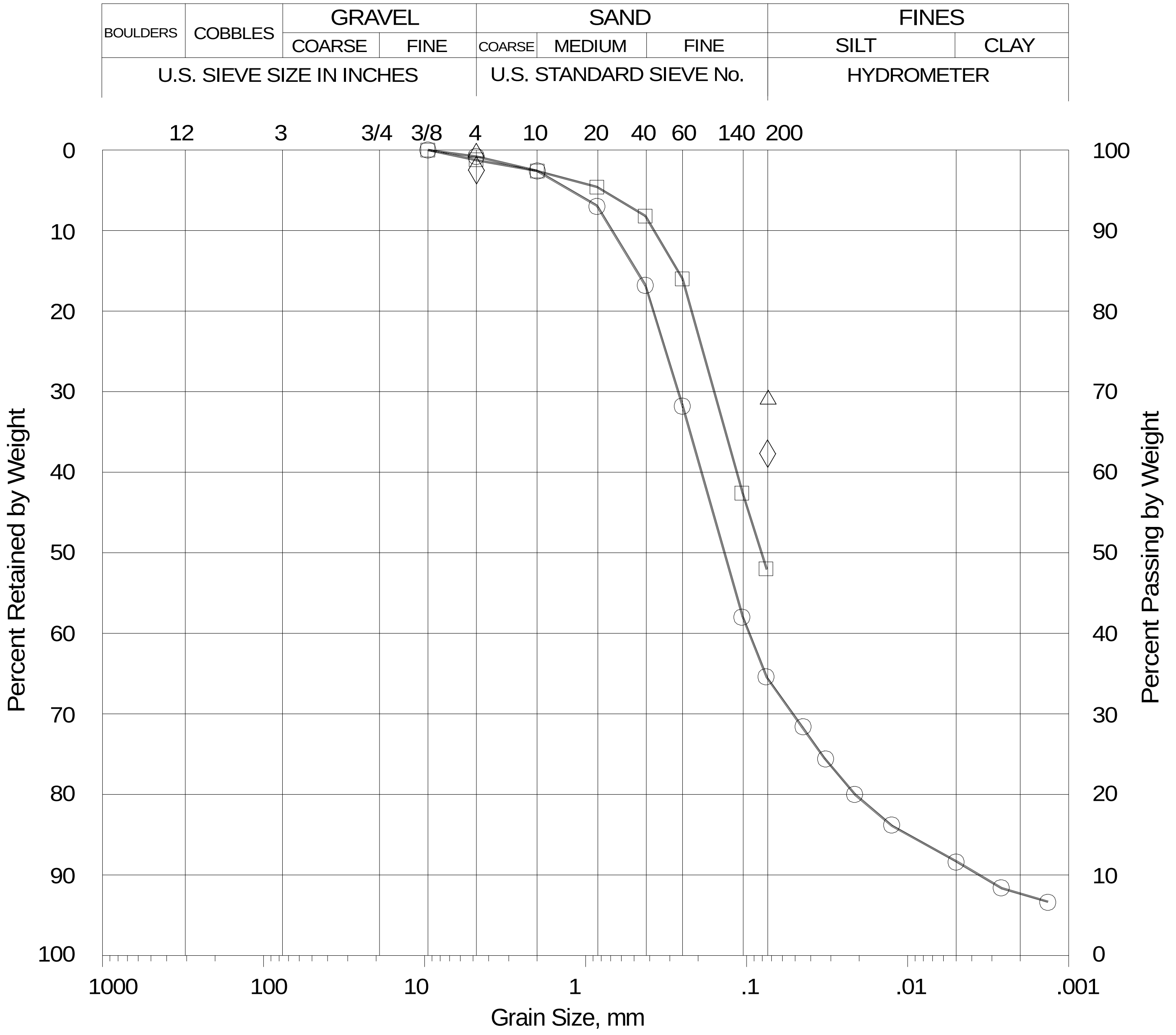
**Grain Size**

**Figure**

**C-2**

(1 of 2)



| TEST SYMBOL | BORING SAMPLE NO. | DEPTH (ft) | GROUP SYMBOL | DESCRIPTION (based on grain size) |
|---|---|---|---|---|
| △ | B-5-2 | 3½-5 | CL | sandy lean clay |
| ○ | B-5-3 | 8½-10 | SC | clayey sand |
| ◇ | B-7-1 | 3-3½ | CL | sandy lean clay |
| □ | B-9-5 | 13½-15 | SC | clayey sand |

**NOTE:** The largest particle (grain) size that could have been sampled from our borings by our sample barrels is a function of the inside diameter of the sample barrels used (see Figure A-1). Therefore, there may be larger particles (e.g., coarse gravel, cobbles or boulders) in the soils sampled than reflected on the boring logs and grain size distribution curves provided in this report.

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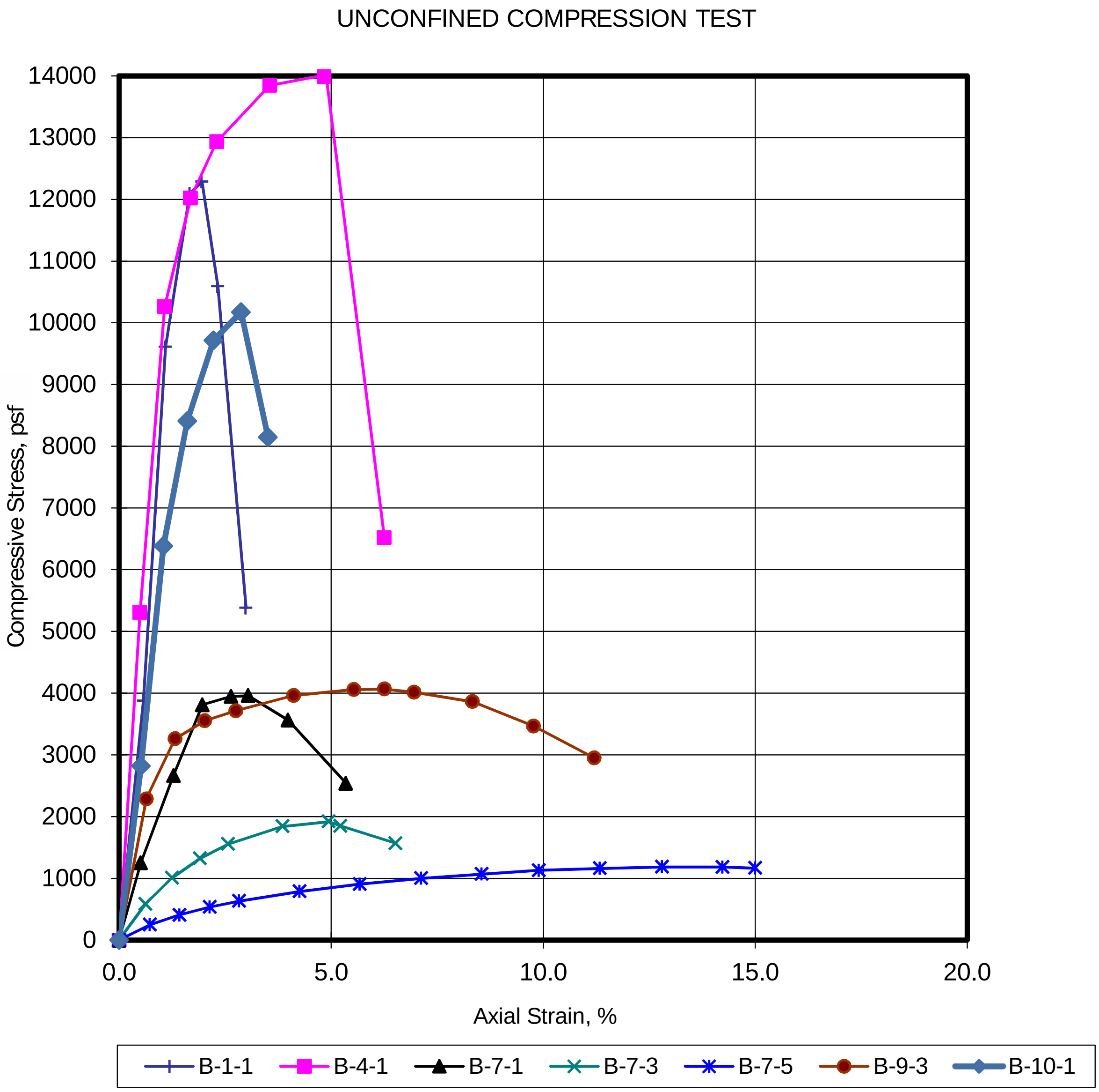
Pittsburg, California

**Grain Size**

**Figure**

**C-2**

(2 of 2)



| **BORING SAMPLE NO.** | **B-1-1** | **B-4-1** | **B-7-1** | **B-7-3** | **B-7-5** | **B-9-3** | **B-10-1** |
|---|---|---|---|---|---|---|---|
| **MAXIMUM UNCONFINED STRESS, psf** | 12,282 | 14,018 | 3,958 | 1,920 | 1,187 | 4,065 | 10,171 |
| **%STRAIN @ PEAK STRESS** | 2.0 | 4.9 | 3.0 | 4.9 | 12.8 | 6.3 | 2.9 |
| **DEPTH, ft.** | 3-3½ | 3-3½ | 3-3½ | 8-8½ | 14½-15 | 8-8½ | 3-3½ |
| **WATER CONTENT, %** | 14 | 17 | 21 | 20 | 22 | 23 | 13 |
| **DRY DENSITY, pcf** | 113 | 109 | 100 | 105 | 106 | 102 | 110 |
| **SATURATION, %** | 77 | 84 | 81 | 89 | 99 | 95 | 66 |

Maximum Unconfined Stress cut-off = 15% strain
Average Strain Rate = 0.07 in/min.

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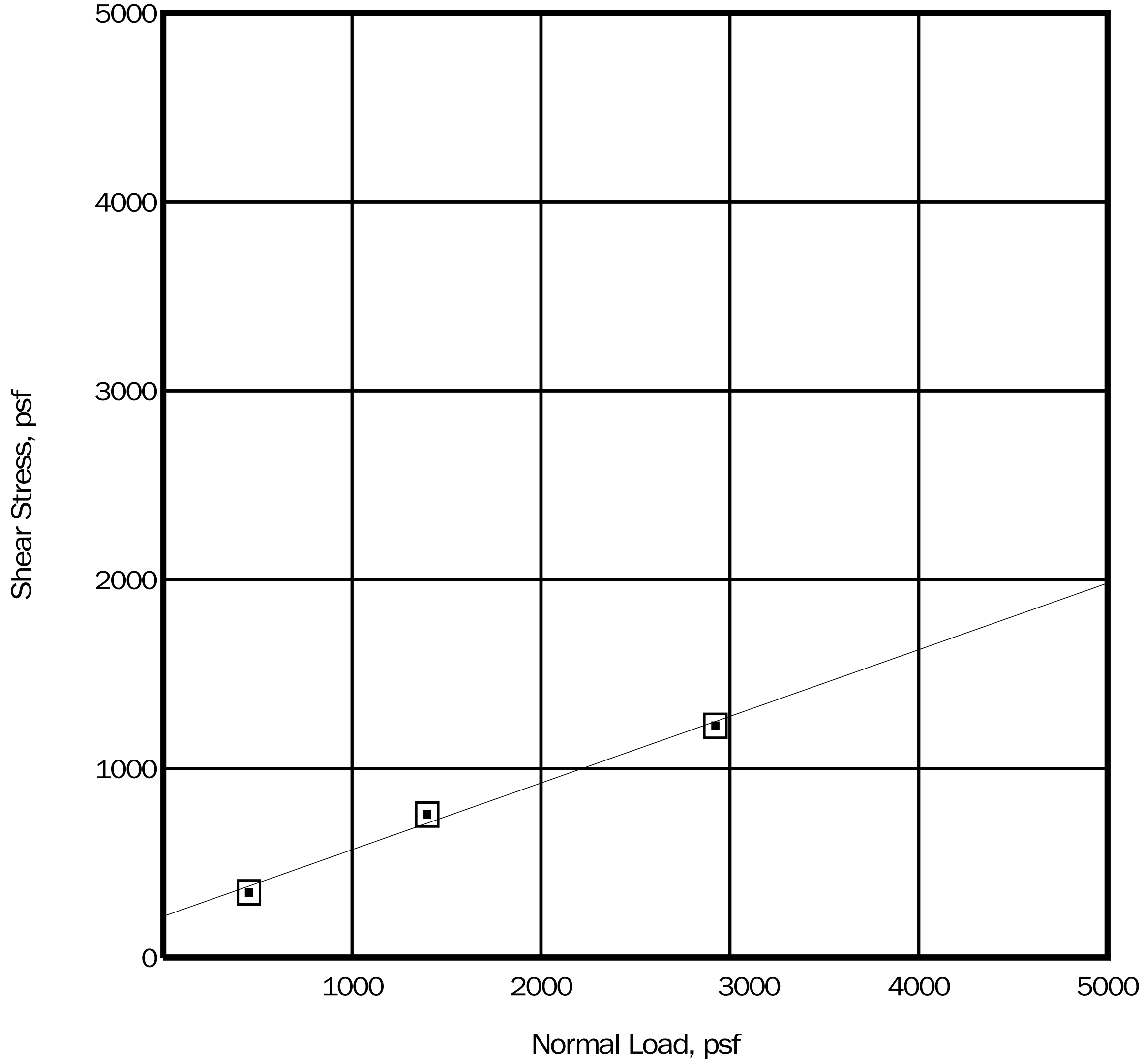
**Unconfined Compression**

**Figure**

**C-3**



| TEST SYMBOL | GRAPH LINE | BORING SAMPLE NO. | DEPTH (ft) | APPARENT COHESION (p.s.f.) | INTERNAL FRICTION ANGLE (degrees) | AVE. DRY DENSITY (pcf)/ MOISTURE CONTENT (%) | |
|---|---|---|---|---|---|---|---|
| | | | | | | BEFORE TEST | AFTER TEST |
| ⊡ | ——— | B-7-3 | 7½-8 | 220 | 19 | 96/21 | 99/25 |

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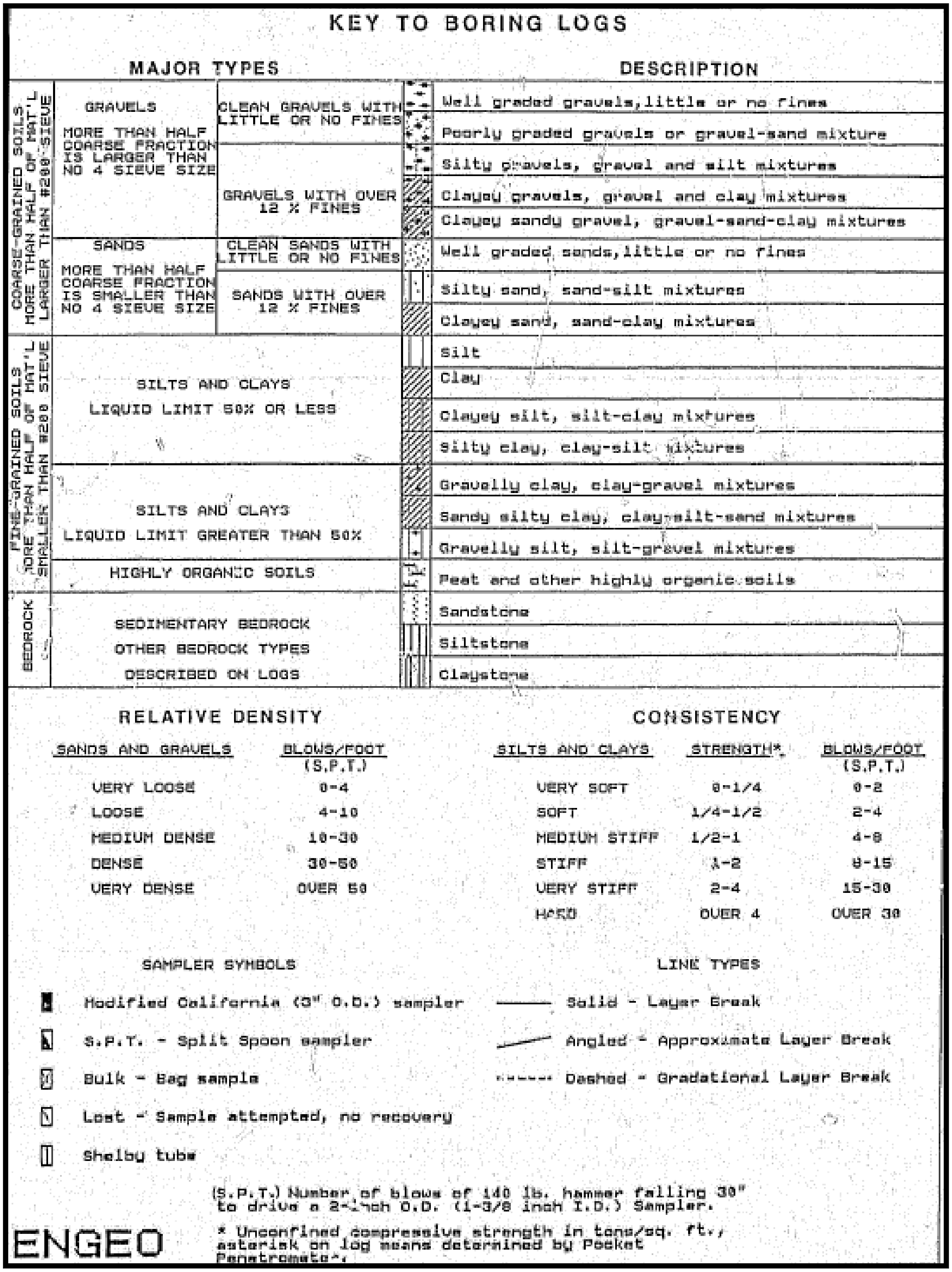
Pittsburg, California

## Direct Shear

Figure
**C-4**

# Appendix D



# KEY TO BORING LOGS

| MAJOR TYPES | | | DESCRIPTION |
|---|---|---|---|
| COARSE-GRAINED SOILS MORE THAN HALF OF MAT'L LARGER THAN #200 SIEVE | GRAVELS<br>MORE THAN HALF COARSE FRACTION IS LARGER THAN NO 4 SIEVE SIZE | CLEAN GRAVELS WITH LITTLE OR NO FINES | Well graded gravels, little or no fines |
| | | | Poorly graded gravels or gravel-sand mixture |
| | | GRAVELS WITH OVER 12 % FINES | Silty gravels, gravel and silt mixtures |
| | | | Clayey gravels, gravel and clay mixtures |
| | | | Clayey sandy gravel, gravel-sand-clay mixtures |
| | SANDS<br>MORE THAN HALF COARSE FRACTION IS SMALLER THAN NO 4 SIEVE SIZE | CLEAN SANDS WITH LITTLE OR NO FINES | Well graded sands, little or no fines |
| | | SANDS WITH OVER 12 % FINES | Silty sand, sand-silt mixtures |
| | | | Clayey sand, sand-clay mixtures |
| FINE-GRAINED SOILS MORE THAN HALF OF MAT'L SMALLER THAN #200 SIEVE | SILTS AND CLAYS<br>LIQUID LIMIT 50% OR LESS | | Silt |
| | | | Clay |
| | | | Clayey silt, silt-clay mixtures |
| | | | Silty clay, clay-silt mixtures |
| | SILTS AND CLAYS<br>LIQUID LIMIT GREATER THAN 50% | | Gravelly clay, clay-gravel mixtures |
| | | | Sandy silty clay, clay-silt-sand mixtures |
| | | | Gravelly silt, silt-gravel mixtures |
| | HIGHLY ORGANIC SOILS | | Peat and other highly organic soils |
| BEDROCK | SEDIMENTARY BEDROCK<br>OTHER BEDROCK TYPES<br>DESCRIBED ON LOGS | | Sandstone |
| | | | Siltstone |
| | | | Claystone |

## RELATIVE DENSITY

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

## CONSISTENCY

| SILTS AND CLAYS | STRENGTH* | BLOWS/FOOT (S.P.T.) |
|---|---|---|
| VERY SOFT | 0-1/4 | 0-2 |
| SOFT | 1/4-1/2 | 2-4 |
| MEDIUM STIFF | 1/2-1 | 4-8 |
| STIFF | 1-2 | 8-15 |
| VERY STIFF | 2-4 | 15-30 |
| HARD | OVER 4 | OVER 30 |

### SAMPLER SYMBOLS

- Modified California (3" O.D.) sampler
- S.P.T. - Split Spoon sampler
- Bulk - Bag sample
- Lost - Sample attempted, no recovery
- Shelby tube

### LINE TYPES

- Solid - Layer Break
- Angled - Approximate Layer Break
- Dashed - Gradational Layer Break

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

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

ENGEO

Reference: Key to Boring Logs (RB-1 through RB-11) - Geotechnical Exploration for City of Pittsburg Water Treatment Plant Expansion (ENGEO, June 1987)

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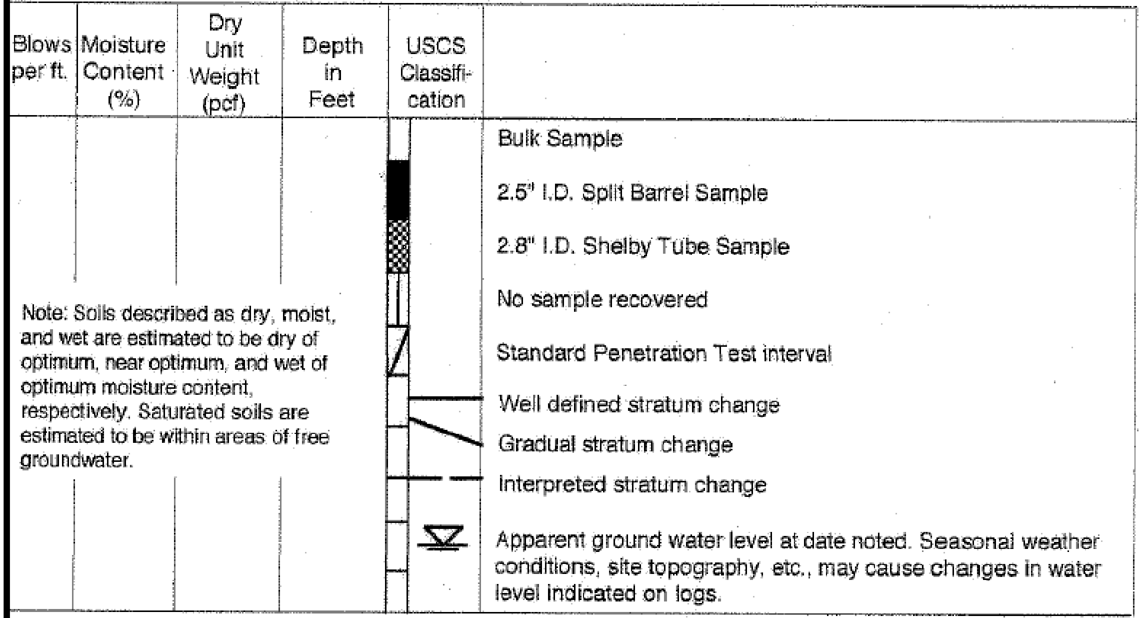
City of Pittsburg
Water Treatment Plant Capital Improvements Project
Pittsburg, California

## Key to Reference Boring Logs

Figure
**D-1**
(1 of 2)

| MAJOR DIVISIONS | | | CLASSIFI-CATION | TYPICAL NAMES |
|---|---|---|---|---|
| COARSE GRAINED SOILS<br>MORE THAN HALF IS LARGER THAN #200 SIEVE | GRAVELS<br>MORE THAN HALF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE | CLEAN GRAVELS WITH LITTLE OR NO FINES | GW | WELL GRADED GRAVELS, GRAVEL - SAND MIXTURES |
| | | | GP | POORLY GRADED GRAVELS, GRAVEL - SAND MIXTURES |
| | | GRAVEL WITH OVER 12% FINES | GM | SILTY GRAVELS, POORLY GRADED GRAVEL - SAND - SILT MIXTURES |
| | | | GC | CLAYEY GRAVELS, POORLY GRADED GRAVEL - SAND - CLAY MIXTURES |
| | SANDS<br>MORE THAN HALF COARSE FRACTION IS SMALLER THAN NO.4 SIEVE SIZE | CLEAN SANDS WITH LITTLE OR NO FINES | SW | WELL GRADED SANDS, GRAVELLY SANDS |
| | | | SP | POORLY GRADED SANDS, GRAVELLY SANDS |
| | | SANDS WITH OVER 12% FINES | SM | SILTY SANDS, POORLY GRADED SAND- SILT MIXTURES |
| | | | SC | CLAYEY SANDS, POORLY GRADED SAND - CLAY MIXTURES |
| FINE GRAINED SOILS<br>MORE THAN HALF IS SMALLER THAN #200 SIEVE | SILTS AND CLAYS<br>LIQUID LIMIT LESS THAN 50 | | ML | INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS, OR CLAYEY SILTS WITH SLIGHT PLASTICITY |
| | | | CL | INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS |
| | | | OL | ORGANIC CLAYS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY |
| | SILTS AND CLAYS<br>LIQUID LIMIT GREATER THAN 50 | | MH | INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS |
| | | | CH | INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS |
| | | | OH | ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS |
| HIGHLY ORGANIC SOILS | | | Pt | PEAT AND OTHER HIGHLY ORGANIC SILTS |

## UNIFIED SOIL CLASSIFICATION SYSTEM



Bulk Sample

2.5" I.D. Split Barrel Sample

2.8" I.D. Shelby Tube Sample

No sample recovered

Standard Penetration Test interval

Well defined stratum change

Gradual stratum change

Interpreted stratum change

Apparent ground water level at date noted. Seasonal weather conditions, site topography, etc., may cause changes in water level indicated on logs.

Note: Soils described as dry, moist, and wet are estimated to be dry of optimum, near optimum, and wet of optimum moisture content, respectively. Saturated soils are estimated to be within areas of free groundwater.

## KEY TO BORING LOG SYMBOLS

Reference: Key to Boring Logs (RB-12 and RB-13) - Berloger Geotechnical Consultants, September 2005

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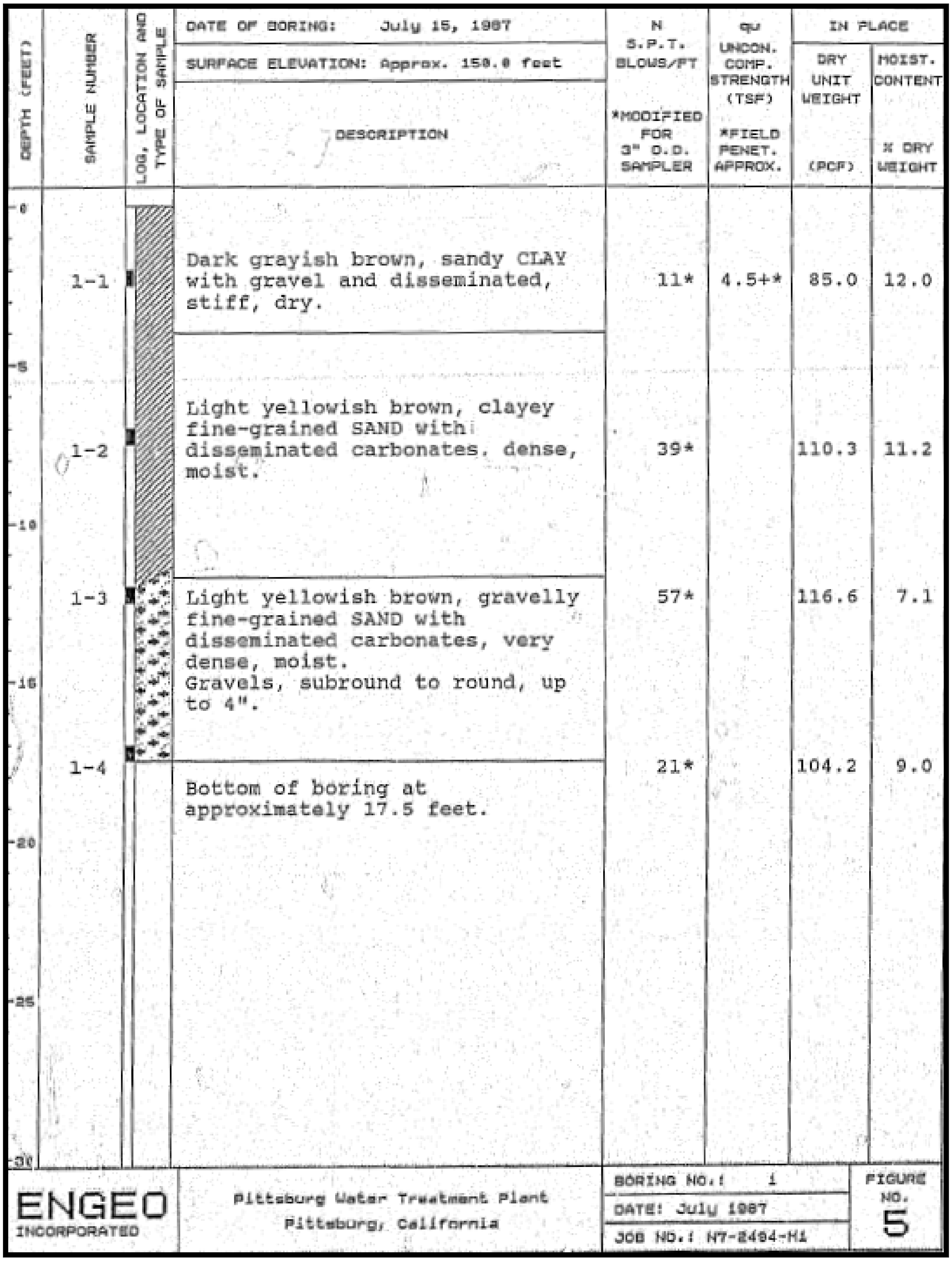
**Key to Reference Boring Logs**

Figure
**D-1**
(2 of 2)



DATE OF BORING: July 15, 1987

SURFACE ELEVATION: Approx. 150.0 feet

| DEPTH (FEET) | SAMPLE NUMBER | LOG, LOCATION AND TYPE OF SAMPLE | DESCRIPTION | N S.P.T. BLOWS/FT *MODIFIED FOR 3" O.D. SAMPLER | qu UNCON. COMP. STRENGTH (TSF) *FIELD PENET. APPROX. | IN PLACE DRY UNIT WEIGHT (PCF) | IN PLACE MOIST. CONTENT % DRY WEIGHT |
|---|---|---|---|---|---|---|---|
| 0 | 1-1 | ▨ | Dark grayish brown, sandy CLAY with gravel and disseminated, stiff, dry. | 11* | 4.5+* | 85.0 | 12.0 |
| 5<br>10 | 1-2 | ▨ | Light yellowish brown, clayey fine-grained SAND with disseminated carbonates, dense, moist. | 39* | | 110.3 | 11.2 |
| 15 | 1-3 | | Light yellowish brown, gravelly fine-grained SAND with disseminated carbonates, very dense, moist.<br>Gravels, subround to round, up to 4". | 57* | | 116.6 | 7.1 |
| 20<br>25<br>30 | 1-4 | | Bottom of boring at approximately 17.5 feet. | 21* | | 104.2 | 9.0 |

| ENGEO INCORPORATED | Pittsburg Water Treatment Plant<br>Pittsburg, California | BORING NO.: 1<br>DATE: July 1987<br>JOB NO.: H7-2494-H1 | FIGURE NO. 5 |
|---|---|---|---|

Reference: Boring No. 1 - Geotechnical Exploration for City of Pittsburg Water Treatment Plant Expansion (ENGEO, June 1987)

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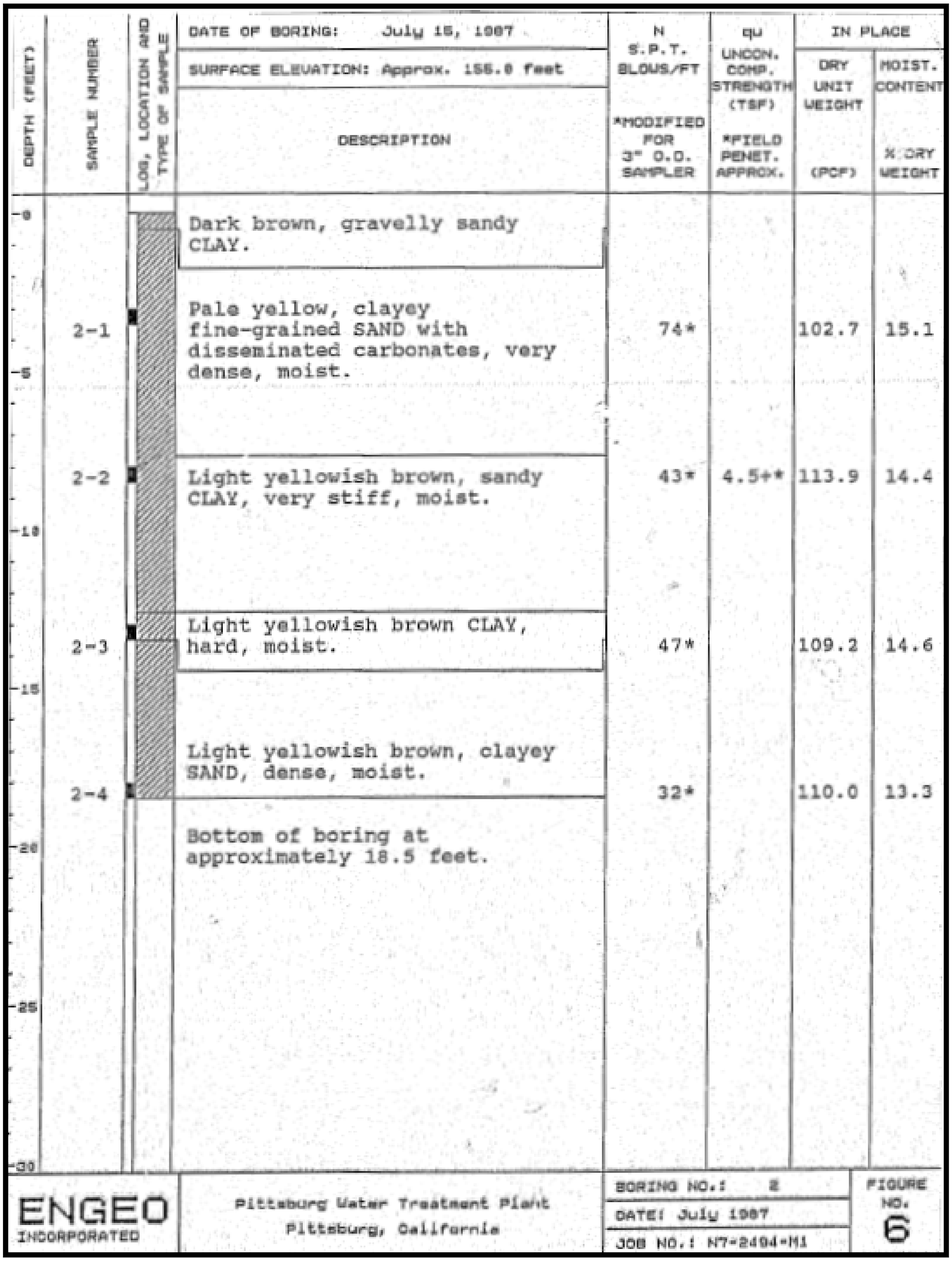
**Log of Reference Boring RB-1**

Figure **D-2**



DATE OF BORING: July 15, 1987

SURFACE ELEVATION: Approx. 156.0 feet

| DEPTH (FEET) | SAMPLE NUMBER | DESCRIPTION | N S.P.T. BLOWS/FT *MODIFIED FOR 3" O.D. SAMPLER | qu UNCON. COMP. STRENGTH (TSF) *FIELD PENET. APPROX. | IN PLACE DRY UNIT WEIGHT (PCF) | IN PLACE MOIST. CONTENT % DRY WEIGHT |
|---|---|---|---|---|---|---|
| 0 | | Dark brown, gravelly sandy CLAY. | | | | |
| | 2-1 | Pale yellow, clayey fine-grained SAND with disseminated carbonates, very dense, moist. | 74* | | 102.7 | 15.1 |
| 5 | | | | | | |
| | 2-2 | Light yellowish brown, sandy CLAY, very stiff, moist. | 43* | 4.5+* | 113.9 | 14.4 |
| 10 | | | | | | |
| | 2-3 | Light yellowish brown CLAY, hard, moist. | 47* | | 109.2 | 14.6 |
| 15 | | Light yellowish brown, clayey SAND, dense, moist. | | | | |
| | 2-4 | | 32* | | 110.0 | 13.3 |
| | | Bottom of boring at approximately 18.5 feet. | | | | |
| 20 | | | | | | |
| 25 | | | | | | |
| 30 | | | | | | |

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Pittsburg, California

BORING NO.: 2
DATE: July 1987
JOB NO.: N7-2494-M1

FIGURE NO. 6

Reference: Boring No. 2 - Geotechnical Exploration for City of Pittsburg Water Treatment Plant Expansion (ENGEO, June 1987)

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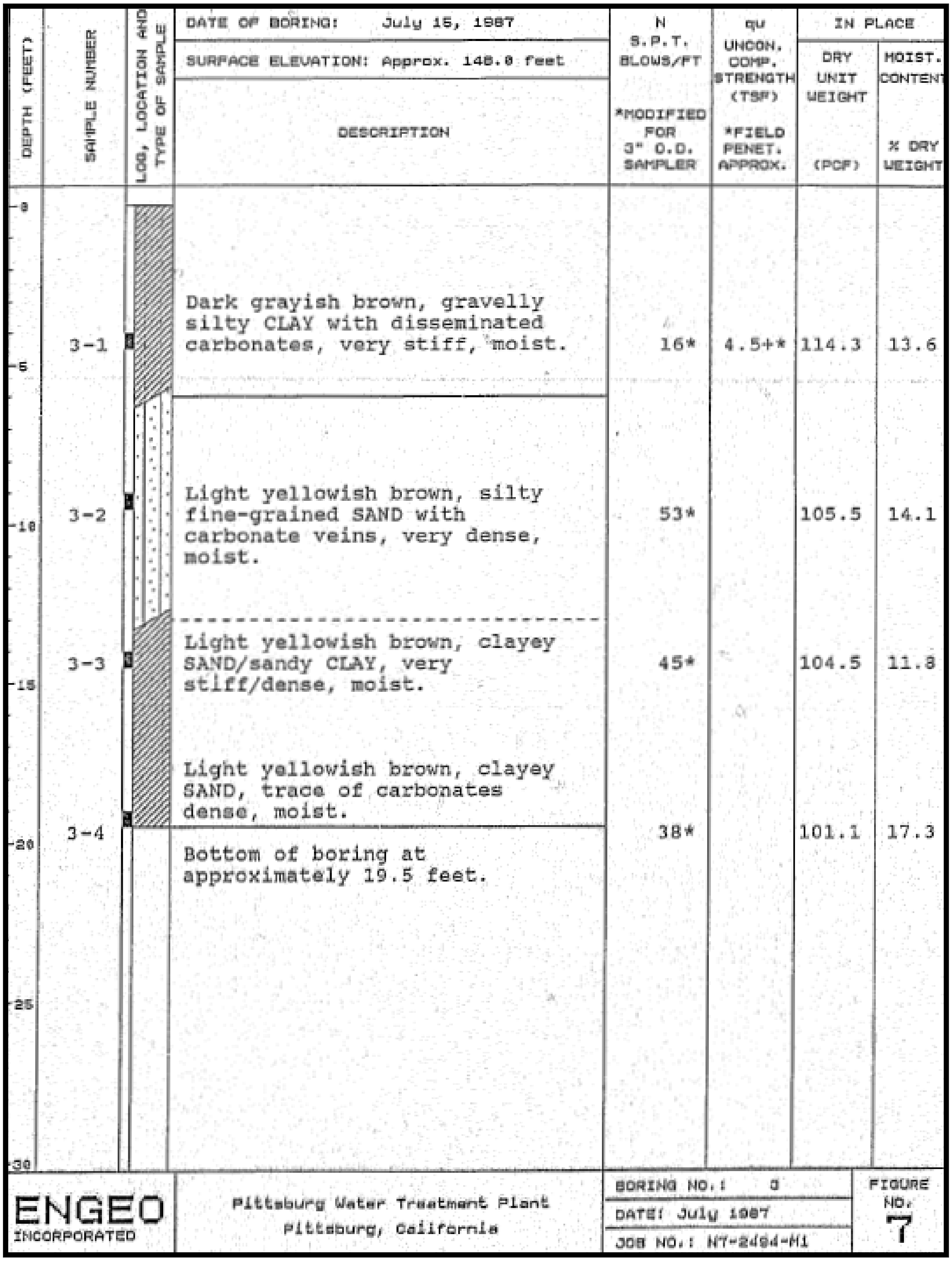
## Log of Reference Boring RB-2

Figure

**D-3**



DATE OF BORING: July 15, 1987

SURFACE ELEVATION: Approx. 148.0 feet

| SAMPLE NUMBER | DESCRIPTION | N S.P.T. BLOWS/FT *MODIFIED FOR 3" O.D. SAMPLER | qu UNCON. COMP. STRENGTH (TSF) *FIELD PENET. APPROX. | IN PLACE DRY UNIT WEIGHT (PCF) | IN PLACE MOIST. CONTENT % DRY WEIGHT |
|---|---|---|---|---|---|
| 3-1 | Dark grayish brown, gravelly silty CLAY with disseminated carbonates, very stiff, moist. | 16* | 4.5+* | 114.3 | 13.6 |
| 3-2 | Light yellowish brown, silty fine-grained SAND with carbonate veins, very dense, moist. | 53* | | 105.5 | 14.1 |
| 3-3 | Light yellowish brown, clayey SAND/sandy CLAY, very stiff/dense, moist. | 45* | | 104.5 | 11.8 |
| | Light yellowish brown, clayey SAND, trace of carbonates dense, moist. | | | | |
| 3-4 | Bottom of boring at approximately 19.5 feet. | 38* | | 101.1 | 17.3 |

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Pittsburg, California

BORING NO.: 3
DATE: July 1987
JOB NO.: NT-2494-H1

FIGURE NO. 7

Reference: Boring No. 3 - Geotechnical Exploration for City of Pittsburg Water Treatment Plant Expansion (ENGEO, June 1987)

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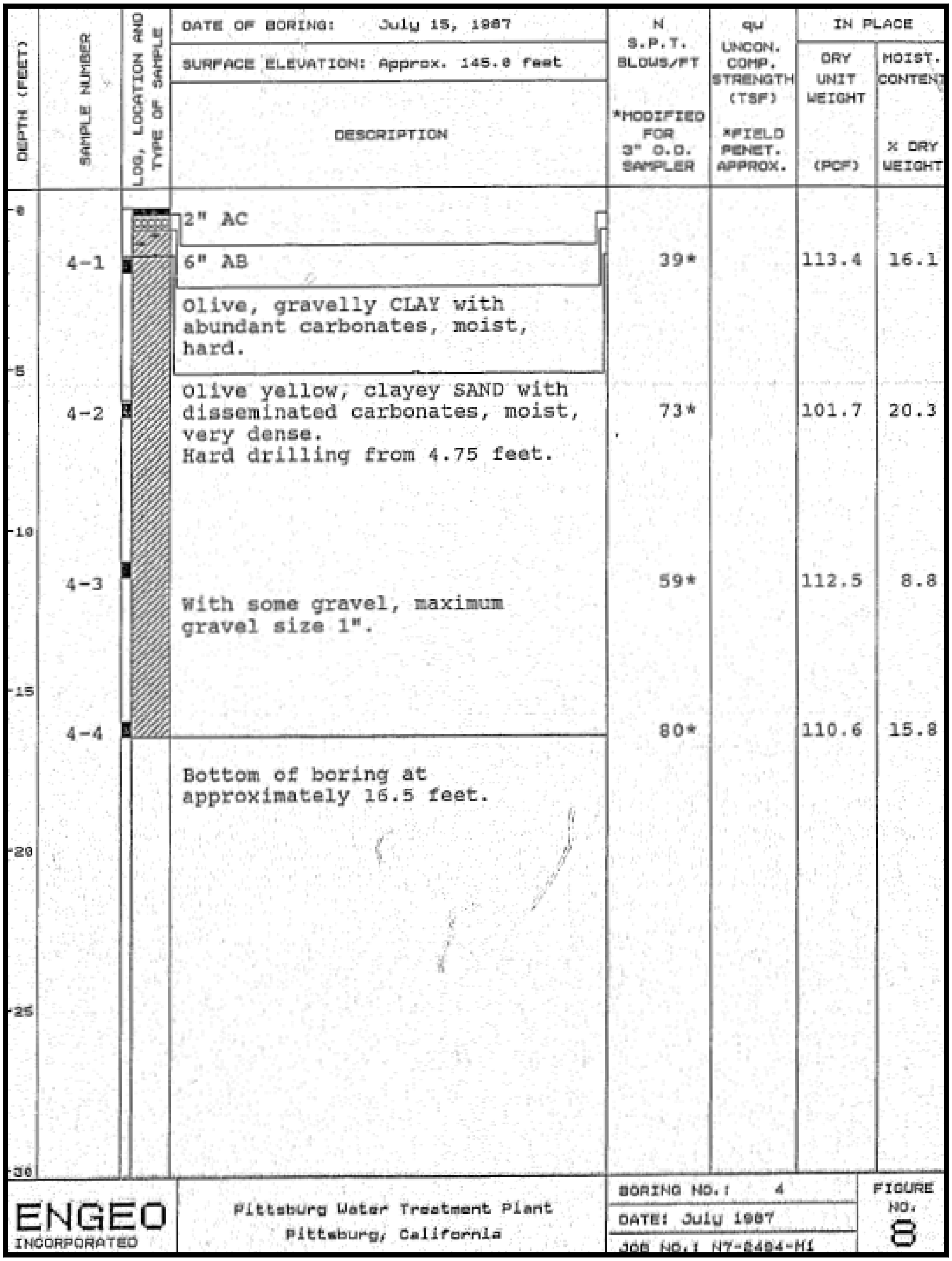
Pittsburg, California

## Log of Reference Boring RB-3

**Figure D-4**



DATE OF BORING: July 15, 1987

SURFACE ELEVATION: Approx. 145.0 feet

| DEPTH (FEET) | SAMPLE NUMBER | LOG, LOCATION AND TYPE OF SAMPLE | DESCRIPTION | N S.P.T. BLOWS/FT *MODIFIED FOR 3" O.D. SAMPLER | qu UNCON. COMP. STRENGTH (TSF) *FIELD PENET. APPROX. | IN PLACE DRY UNIT WEIGHT (PCF) | IN PLACE MOIST. CONTENT % DRY WEIGHT |
|---|---|---|---|---|---|---|---|
| 0 | | | 2" AC | | | | |
| | 4-1 | | 6" AB | 39* | | 113.4 | 16.1 |
| | | | Olive, gravelly CLAY with abundant carbonates, moist, hard. | | | | |
| 5 | | | | | | | |
| | 4-2 | | Olive yellow, clayey SAND with disseminated carbonates, moist, very dense.<br>Hard drilling from 4.75 feet. | 73* | | 101.7 | 20.3 |
| 10 | | | | | | | |
| | 4-3 | | With some gravel, maximum gravel size 1". | 59* | | 112.5 | 8.8 |
| 15 | | | | | | | |
| | 4-4 | | | 80* | | 110.6 | 15.8 |
| | | | Bottom of boring at approximately 16.5 feet. | | | | |
| 20 | | | | | | | |
| 25 | | | | | | | |
| 30 | | | | | | | |

ENGEO INCORPORATED

Pittsburg Water Treatment Plant
Pittsburg, California

BORING NO.: 4
DATE: July 1987
JOB NO.: N7-2494-M1

FIGURE NO. 8

Reference: Boring No. 4 - Geotechnical Exploration for City of Pittsburg Water Treatment Plant Expansion (ENGEO, June 1987)

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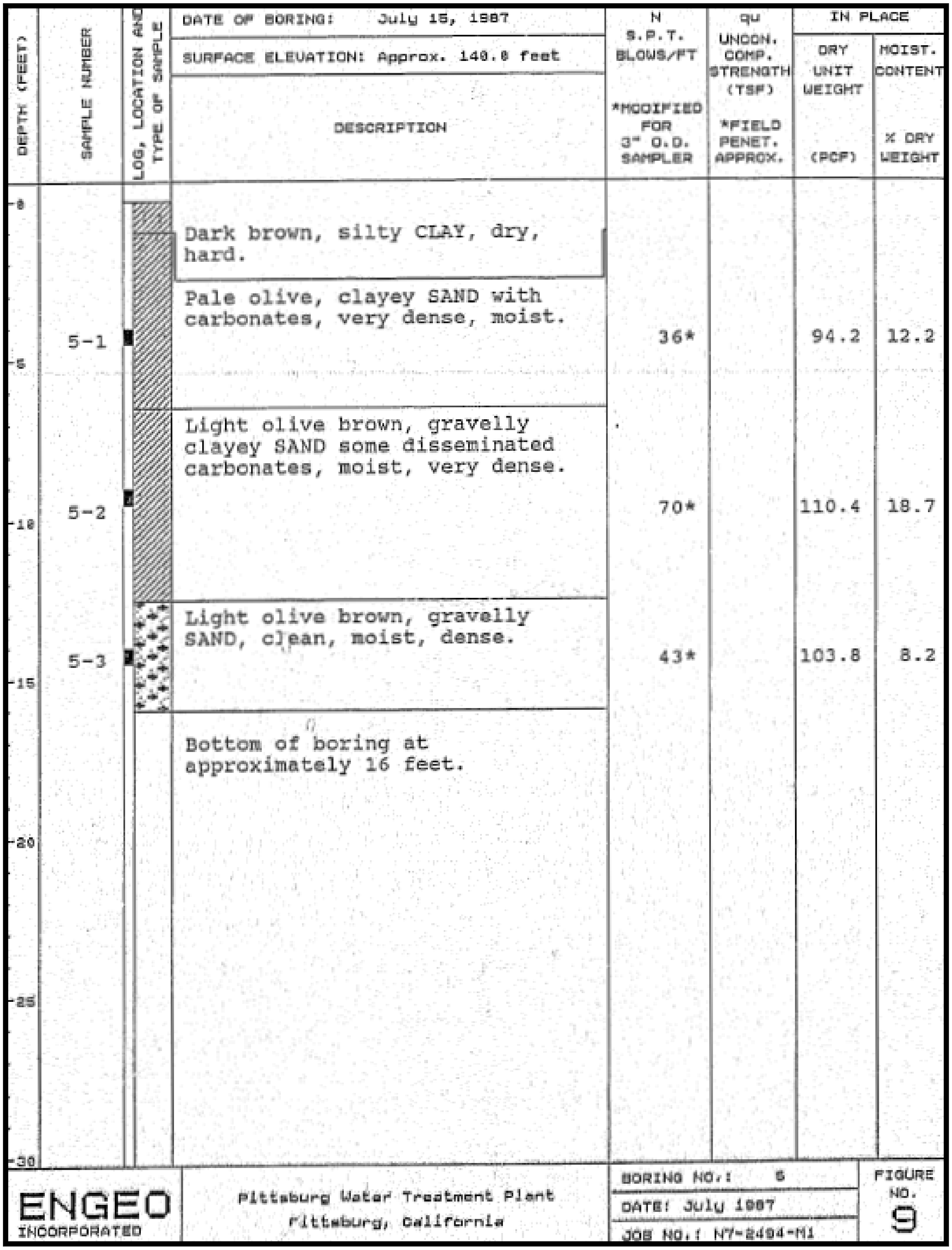
Pittsburg, California

## Log of Reference Boring RB-4

Figure
**D-5**



| DEPTH (FEET) | SAMPLE NUMBER | LOG, LOCATION AND TYPE OF SAMPLE | DATE OF BORING: July 15, 1987<br>SURFACE ELEVATION: Approx. 140.0 feet<br>DESCRIPTION | N S.P.T. BLOWS/FT *MODIFIED FOR 3" O.D. SAMPLER | qu UNCON. COMP. STRENGTH (TSF) *FIELD PENET. APPROX. | IN PLACE DRY UNIT WEIGHT (PCF) | IN PLACE MOIST. CONTENT % DRY WEIGHT |
|---|---|---|---|---|---|---|---|
| 0 | | | Dark brown, silty CLAY, dry, hard. | | | | |
| | 5-1 | | Pale olive, clayey SAND with carbonates, very dense, moist. | 36* | | 94.2 | 12.2 |
| 5 | | | | | | | |
| | 5-2 | | Light olive brown, gravelly clayey SAND some disseminated carbonates, moist, very dense. | 70* | | 110.4 | 18.7 |
| 10 | | | | | | | |
| | 5-3 | | Light olive brown, gravelly SAND, clean, moist, dense. | 43* | | 103.8 | 8.2 |
| 15 | | | | | | | |
| | | | Bottom of boring at approximately 16 feet. | | | | |
| 20 | | | | | | | |
| 25 | | | | | | | |
| 30 | | | | | | | |

| | | | |
|---|---|---|---|
| ENGEO INCORPORATED | Pittsburg Water Treatment Plant<br>Pittsburg, California | BORING NO.: 5<br>DATE: July 1987<br>JOB NO.: N7-2494-M1 | FIGURE NO. 9 |

Reference: Boring No. 5 - Geotechnical Exploration for City of Pittsburg Water Treatment Plant Expansion (ENGEO, June 1987)

JACOBS ASSOCIATES
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June 2013

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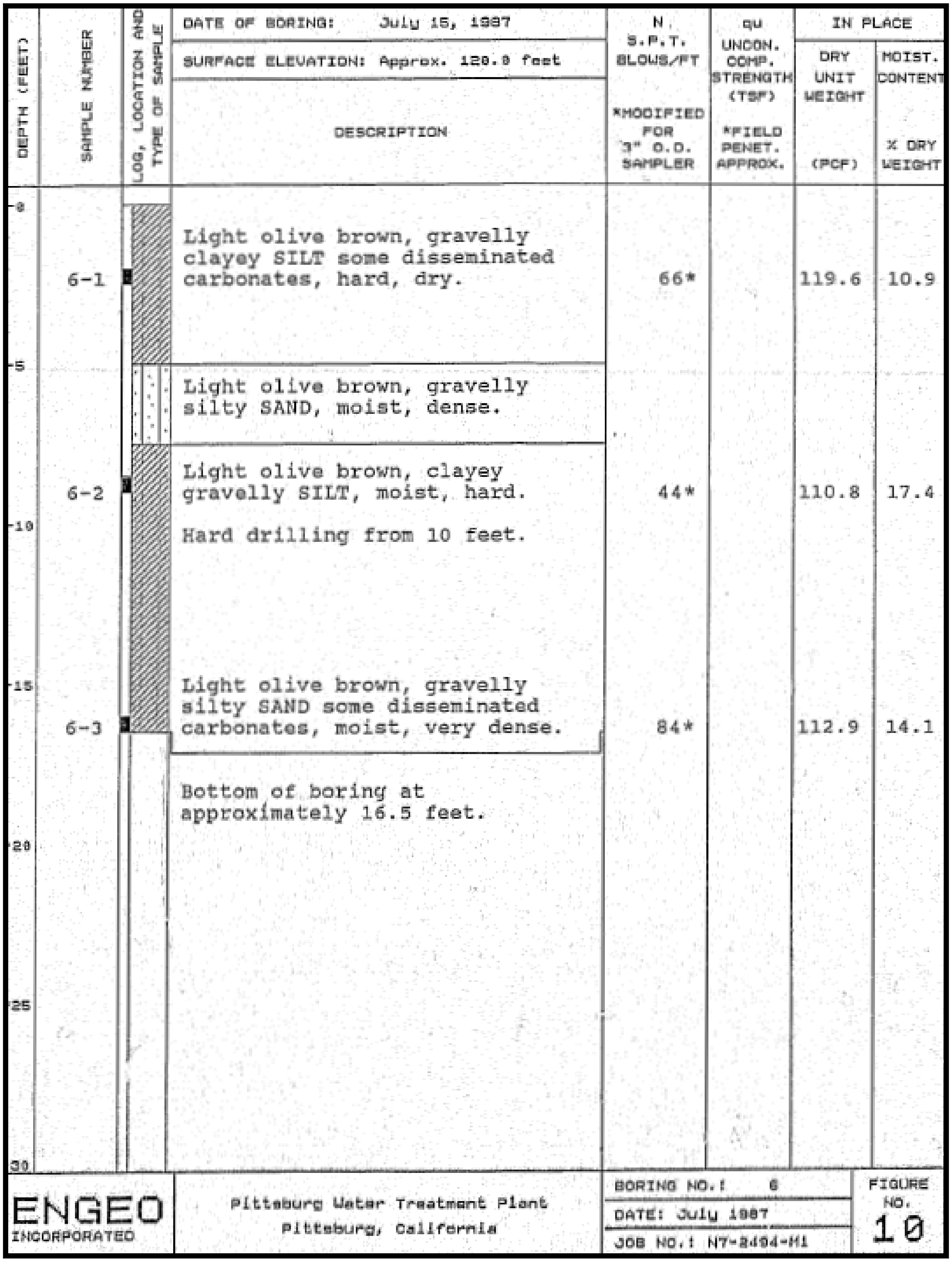
Water Treatment Plant Capital Improvements Project
Pittsburg, California

## Log of Reference Boring RB-5

**Figure**

**D-6**



DATE OF BORING: July 15, 1987

SURFACE ELEVATION: Approx. 120.0 feet

| DEPTH (FEET) | SAMPLE NUMBER | LOG, LOCATION AND TYPE OF SAMPLE | DESCRIPTION | N S.P.T. BLOWS/FT *MODIFIED FOR 3" O.D. SAMPLER | qu UNCON. COMP. STRENGTH (TSF) *FIELD PENET. APPROX. | IN PLACE DRY UNIT WEIGHT (PCF) | IN PLACE MOIST. CONTENT % DRY WEIGHT |
|---|---|---|---|---|---|---|---|
| 0 | 6-1 | | Light olive brown, gravelly clayey SILT some disseminated carbonates, hard, dry. | 66* | | 119.6 | 10.9 |
| 5 | | | Light olive brown, gravelly silty SAND, moist, dense. | | | | |
| | 6-2 | | Light olive brown, clayey gravelly SILT, moist, hard.<br>Hard drilling from 10 feet. | 44* | | 110.8 | 17.4 |
| 15 | 6-3 | | Light olive brown, gravelly silty SAND some disseminated carbonates, moist, very dense. | 84* | | 112.9 | 14.1 |
| | | | Bottom of boring at approximately 16.5 feet. | | | | |

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Pittsburg Water Treatment Plant
Pittsburg, California

BORING NO.: 6
DATE: July 1987
JOB NO.: N7-2494-H1

FIGURE NO.
10

Reference: Boring No. 6 - Geotechnical Exploration for City of Pittsburg Water Treatment Plant Expansion (ENGEO, June 1987)

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File No. 5003.0

June 2013

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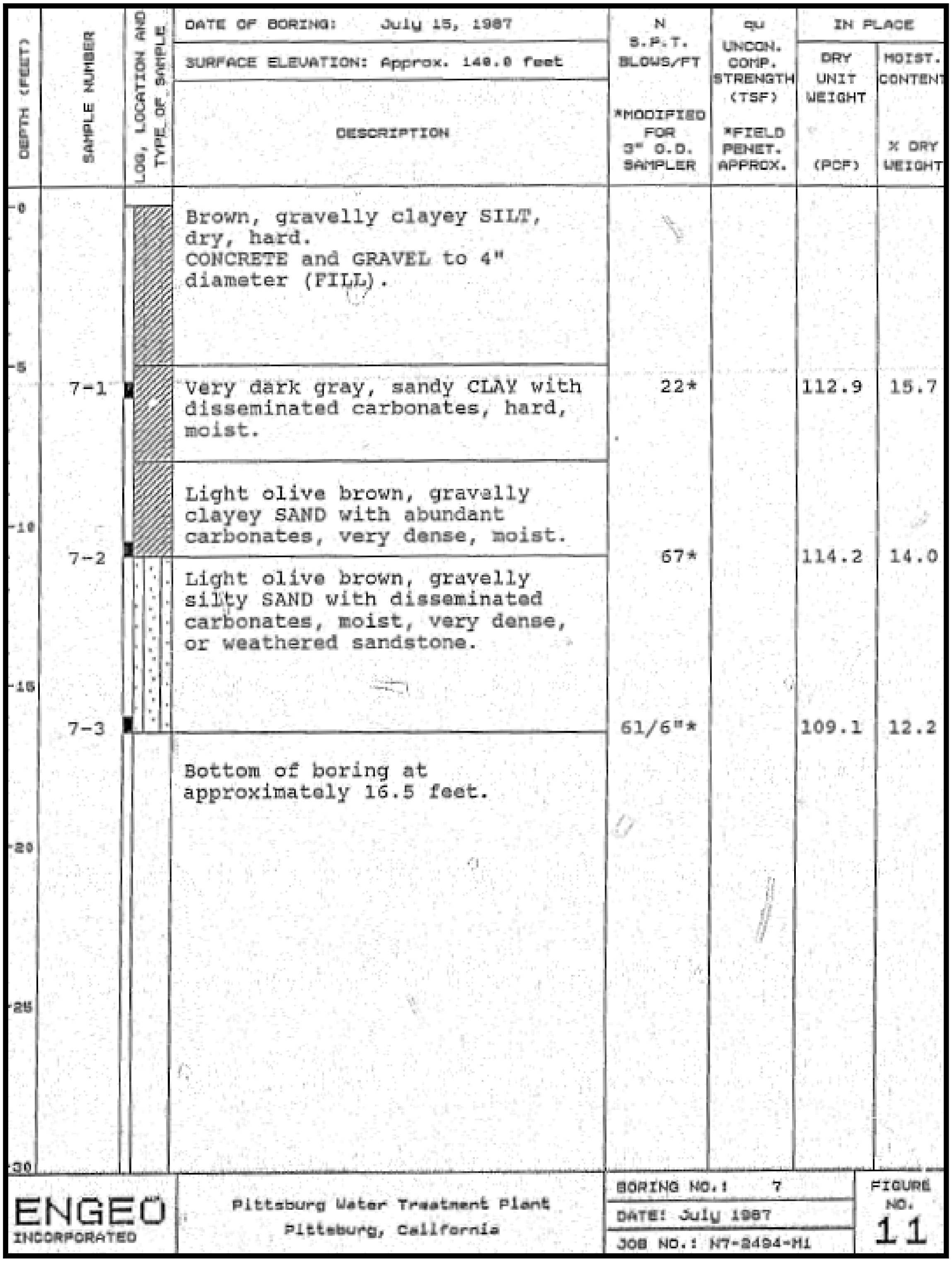
Pittsburg, California

## Log of Reference Boring RB-6

Figure

D-7



DATE OF BORING: July 15, 1987

SURFACE ELEVATION: Approx. 140.0 feet

| DEPTH (FEET) | SAMPLE NUMBER | LOG, LOCATION AND TYPE OF SAMPLE | DESCRIPTION | N S.P.T. BLOWS/FT *MODIFIED FOR 3" O.D. SAMPLER | qu UNCON. COMP. STRENGTH (TSF) *FIELD PENET. APPROX. | IN PLACE | |
|---|---|---|---|---|---|---|---|
| | | | | | | DRY UNIT WEIGHT (PCF) | MOIST. CONTENT % DRY WEIGHT |
| 0 | | ▨ | Brown, gravelly clayey SILT, dry, hard. CONCRETE and GRAVEL to 4" diameter (FILL). | | | | |
| 5 | 7-1 | ■ ▨ | Very dark gray, sandy CLAY with disseminated carbonates, hard, moist. | 22* | | 112.9 | 15.7 |
| 10 | | ▨ | Light olive brown, gravelly clayey SAND with abundant carbonates, very dense, moist. | | | | |
| | 7-2 | ■ | Light olive brown, gravelly silty SAND with disseminated carbonates, moist, very dense, or weathered sandstone. | 67* | | 114.2 | 14.0 |
| 15 | 7-3 | ■ | | 61/6"* | | 109.1 | 12.2 |
| | | | Bottom of boring at approximately 16.5 feet. | | | | |
| 20 | | | | | | | |
| 25 | | | | | | | |
| 30 | | | | | | | |

ENGEO
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Pittsburg Water Treatment Plant
Pittsburg, California

BORING NO.: 7
DATE: July 1987
JOB NO.: N7-2494-H1

FIGURE NO. 11

Reference: Boring No. 7 - Geotechnical Exploration for City of Pittsburg Water Treatment Plant Expansion (ENGEO, June 1987)

JACOBS ASSOCIATES
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File No. 5003.0 | June 2013

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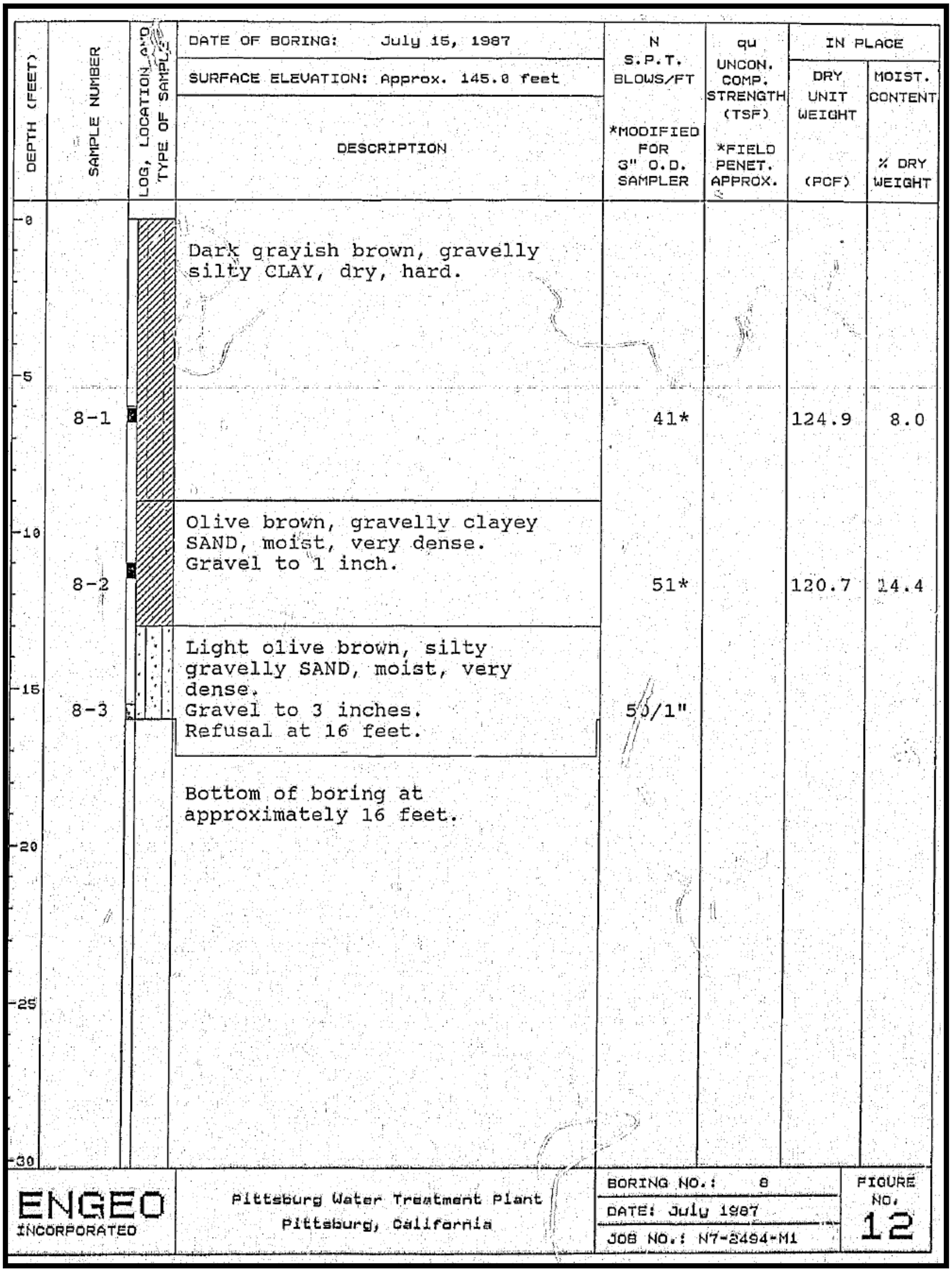
Water Treatment Plant Capital Improvements Project
Pittsburg, California

**Log of Reference Boring RB-7**

Figure
**D-8**



DATE OF BORING: July 15, 1987

SURFACE ELEVATION: Approx. 145.0 feet

| DEPTH (FEET) | SAMPLE NUMBER | LOG, LOCATION AND TYPE OF SAMPLE | DESCRIPTION | N S.P.T. BLOWS/FT *MODIFIED FOR 3" O.D. SAMPLER | qu UNCON. COMP. STRENGTH (TSF) *FIELD PENET. APPROX. | IN PLACE DRY UNIT WEIGHT (PCF) | IN PLACE MOIST. CONTENT % DRY WEIGHT |
|---|---|---|---|---|---|---|---|
| 0 | | ▨ | Dark grayish brown, gravelly silty CLAY, dry, hard. | | | | |
| 5 | 8-1 | ■ | | 41* | | 124.9 | 8.0 |
| 10 | | ▨ | Olive brown, gravelly clayey SAND, moist, very dense. Gravel to 1 inch. | | | | |
| | 8-2 | ■ | | 51* | | 120.7 | 14.4 |
| 15 | 8-3 | | Light olive brown, silty gravelly SAND, moist, very dense. Gravel to 3 inches. Refusal at 16 feet. | 50/1" | | | |
| | | | Bottom of boring at approximately 16 feet. | | | | |
| 20 | | | | | | | |
| 25 | | | | | | | |
| 30 | | | | | | | |

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Pittsburg Water Treatment Plant
Pittsburg, California

BORING NO.: 8
DATE: July 1987
JOB NO.: N7-2494-M1

FIGURE NO. 12

Reference: Boring No. 12 - Geotechnical Exploration for City of Pittsburg 6 MG Water Storage Reservoir Project (ENGEO, June 1987)

JACOBS ASSOCIATES
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File No. 5003.0
June 2013

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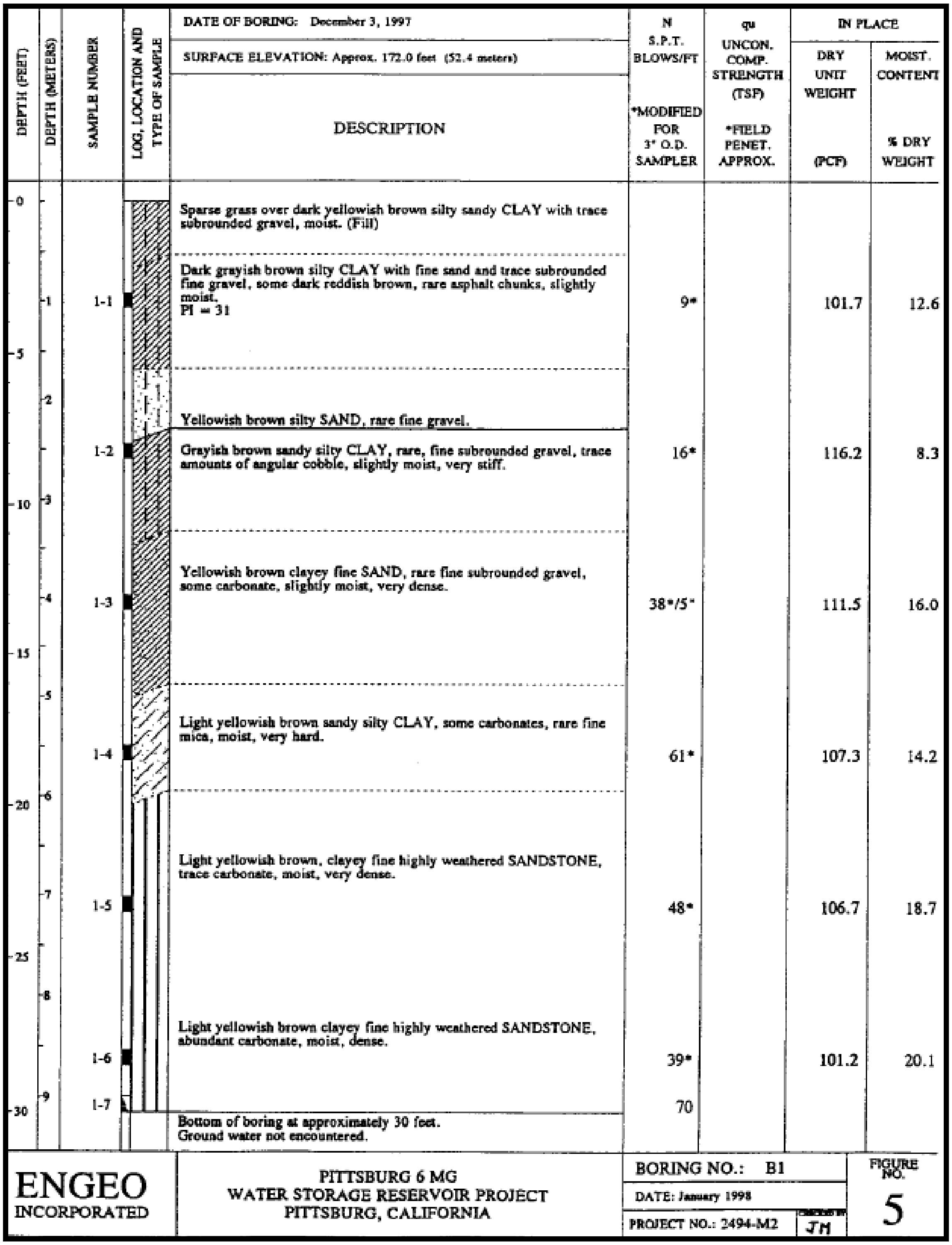
Water Treatment Plant Capital Improvements Project
Pittsburg, California

## Log of Reference Boring RB-8

Figure
**D-9**



DATE OF BORING: December 3, 1997

SURFACE ELEVATION: Approx. 172.0 feet (52.4 meters)

| DEPTH (FEET) | DEPTH (METERS) | SAMPLE NUMBER | LOG, LOCATION AND TYPE OF SAMPLE | DESCRIPTION | N S.P.T. BLOWS/FT *MODIFIED FOR 3" O.D. SAMPLER | qu UNCON. COMP. STRENGTH (TSF) *FIELD PENET. APPROX. | IN PLACE DRY UNIT WEIGHT (PCF) | IN PLACE MOIST. CONTENT % DRY WEIGHT |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | Sparse grass over dark yellowish brown silty sandy CLAY with trace subrounded gravel, moist. (Fill) | | | | |
| | 1 | 1-1 | | Dark grayish brown silty CLAY with fine sand and trace subrounded fine gravel, some dark reddish brown, rare asphalt chunks, slightly moist.<br>PI = 31 | 9* | | 101.7 | 12.6 |
| 5 | 2 | | | Yellowish brown silty SAND, rare fine gravel. | | | | |
| | | 1-2 | | Grayish brown sandy silty CLAY, rare, fine subrounded gravel, trace amounts of angular cobble, slightly moist, very stiff. | 16* | | 116.2 | 8.3 |
| 10 | 3 | | | | | | | |
| | 4 | 1-3 | | Yellowish brown clayey fine SAND, rare fine subrounded gravel, some carbonate, slightly moist, very dense. | 38*/5" | | 111.5 | 16.0 |
| 15 | 5 | | | | | | | |
| | | 1-4 | | Light yellowish brown sandy silty CLAY, some carbonates, rare fine mica, moist, very hard. | 61* | | 107.3 | 14.2 |
| 20 | 6 | | | | | | | |
| | | | | Light yellowish brown, clayey fine highly weathered SANDSTONE, trace carbonate, moist, very dense. | | | | |
| | 7 | 1-5 | | | 48* | | 106.7 | 18.7 |
| 25 | 8 | | | | | | | |
| | | | | Light yellowish brown clayey fine highly weathered SANDSTONE, abundant carbonate, moist, dense. | | | | |
| | | 1-6 | | | 39* | | 101.2 | 20.1 |
| | 9 | 1-7 | | | 70 | | | |
| 30 | | | | Bottom of boring at approximately 30 feet.<br>Ground water not encountered. | | | | |

ENGEO
INCORPORATED

PITTSBURG 6 MG
WATER STORAGE RESERVOIR PROJECT
PITTSBURG, CALIFORNIA

BORING NO.: B1

DATE: January 1998

PROJECT NO.: 2494-M2

JM

FIGURE NO.
5

Reference: Boring No. 1 - Geotechnical Exploration for City of Pittsburg 6 MG Water Storage Reservoir Project (ENGEO, December 1997)

JACOBS ASSOCIATES
Engineers/Consultants

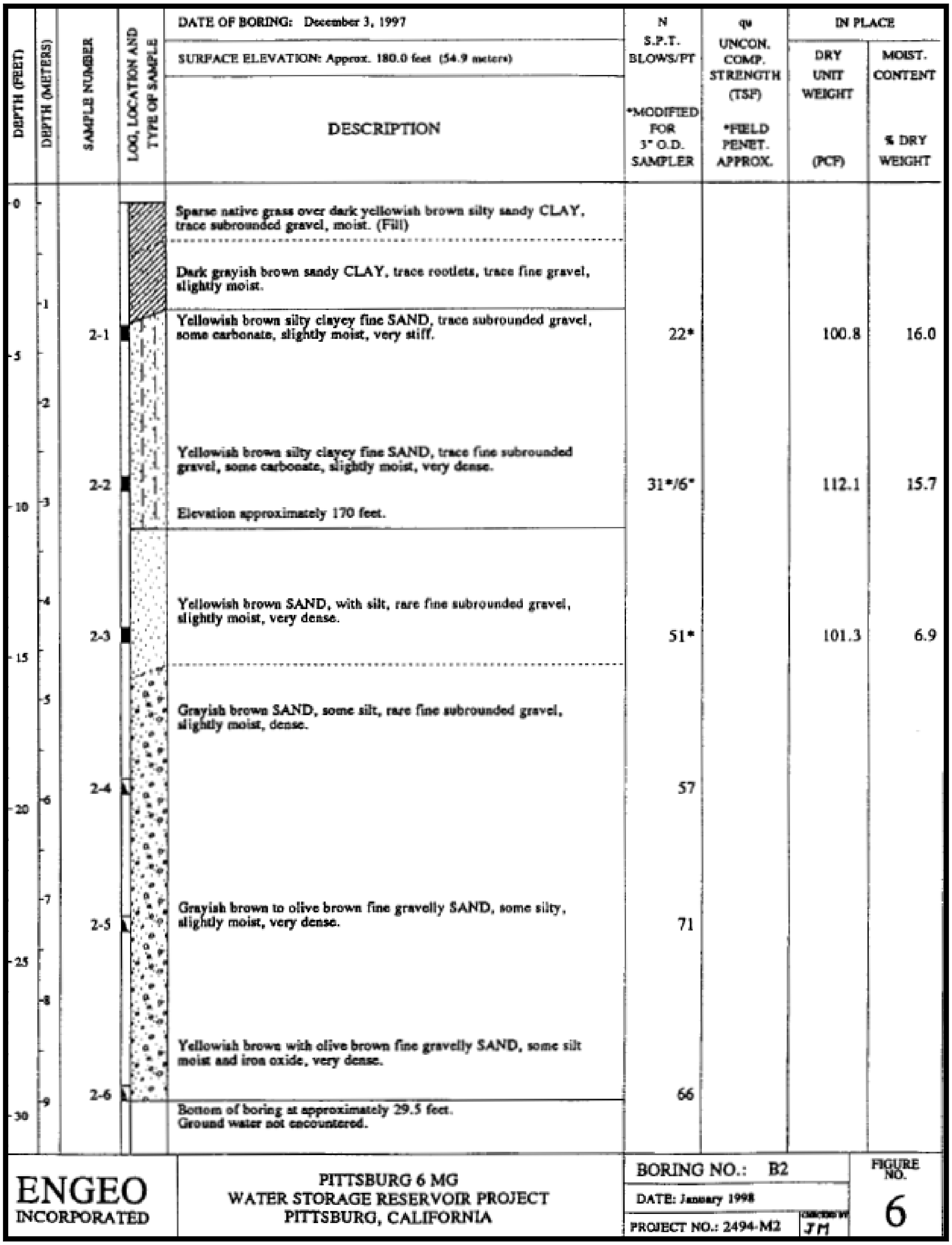
| File No. 5003.0 | June 2013 |
|---|---|

**Brown and Caldwell**

City of Pittsburg
Water Treatment Plant Capital Improvements Project
Pittsburg, California

## Log of Reference Boring RB-9

Figure
**D-10**



DATE OF BORING: December 3, 1997

SURFACE ELEVATION: Approx. 180.0 feet (54.9 meters)

| DEPTH (FEET) | DEPTH (METERS) | SAMPLE NUMBER | LOG, LOCATION AND TYPE OF SAMPLE | DESCRIPTION | N S.P.T. BLOWS/FT *MODIFIED FOR 3" O.D. SAMPLER | qu UNCON. COMP. STRENGTH (TSF) *FIELD PENET. APPROX. | IN PLACE DRY UNIT WEIGHT (PCF) | IN PLACE MOIST. CONTENT % DRY WEIGHT |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | Sparse native grass over dark yellowish brown silty sandy CLAY, trace subrounded gravel, moist. (Fill) | | | | |
| | 1 | | | Dark grayish brown sandy CLAY, trace rootlets, trace fine gravel, slightly moist. | | | | |
| 5 | | 2-1 | | Yellowish brown silty clayey fine SAND, trace subrounded gravel, some carbonate, slightly moist, very stiff. | 22* | | 100.8 | 16.0 |
| | 2 | | | | | | | |
| 10 | 3 | 2-2 | | Yellowish brown silty clayey fine SAND, trace fine subrounded gravel, some carbonate, slightly moist, very dense.<br>Elevation approximately 170 feet. | 31*/6* | | 112.1 | 15.7 |
| 15 | 4 | 2-3 | | Yellowish brown SAND, with silt, rare fine subrounded gravel, slightly moist, very dense. | 51* | | 101.3 | 6.9 |
| | 5 | | | Grayish brown SAND, some silt, rare fine subrounded gravel, slightly moist, dense. | | | | |
| 20 | 6 | 2-4 | | | 57 | | | |
| 25 | 7 | 2-5 | | Grayish brown to olive brown fine gravelly SAND, some silty, slightly moist, very dense. | 71 | | | |
| 30 | 8<br>9 | 2-6 | | Yellowish brown with olive brown fine gravelly SAND, some silt moist and iron oxide, very dense. | 66 | | | |
| | | | | Bottom of boring at approximately 29.5 feet.<br>Ground water not encountered. | | | | |

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PITTSBURG 6 MG
WATER STORAGE RESERVOIR PROJECT
PITTSBURG, CALIFORNIA

BORING NO.: B2
DATE: January 1998
PROJECT NO.: 2494-M2
CHECKED BY JM
FIGURE NO. 6

Reference: Boring No. 2 - Geotechnical Exploration for City of Pittsburg 6 MG Water Storage Reservoir Project (ENGEO, December 1997)

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File No. 5003.0 | June 2013

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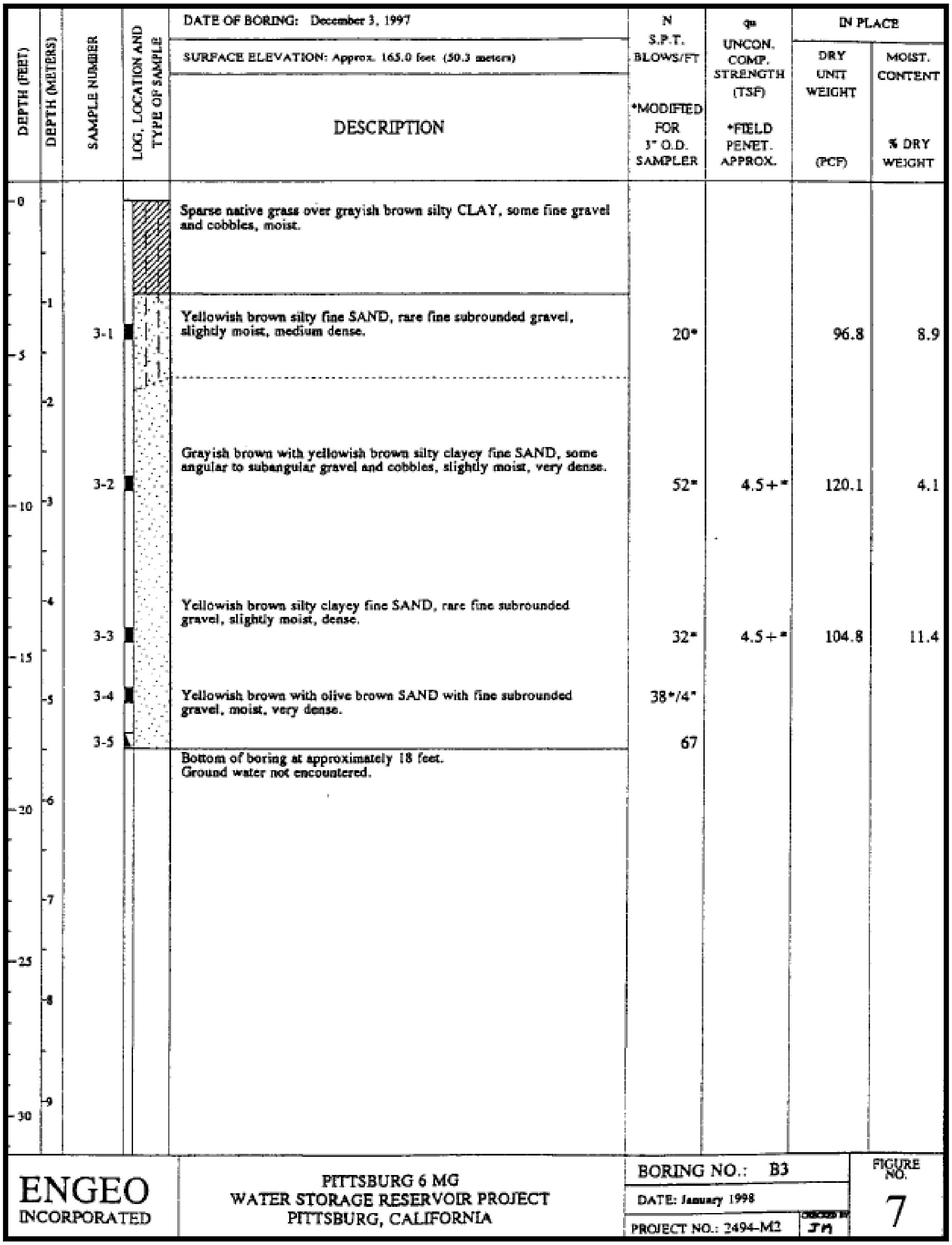
City of Pittsburg
Water Treatment Plant Capital Improvements Project
Pittsburg, California

## Log of Reference Boring RB-10

Figure
**D-11**



DATE OF BORING: December 3, 1997

SURFACE ELEVATION: Approx. 165.0 feet (50.3 meters)

| DEPTH (FEET) | DEPTH (METERS) | SAMPLE NUMBER | LOG, LOCATION AND TYPE OF SAMPLE | DESCRIPTION | N S.P.T. BLOWS/FT *MODIFIED FOR 3" O.D. SAMPLER | qu UNCON. COMP. STRENGTH (TSF) *FIELD PENET. APPROX. | IN PLACE DRY UNIT WEIGHT (PCF) | IN PLACE MOIST. CONTENT % DRY WEIGHT |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | Sparse native grass over grayish brown silty CLAY, some fine gravel and cobbles, moist. | | | | |
| | 1 | 3-1 | | Yellowish brown silty fine SAND, rare fine subrounded gravel, slightly moist, medium dense. | 20* | | 96.8 | 8.9 |
| 5 | 2 | 3-2 | | Grayish brown with yellowish brown silty clayey fine SAND, some angular to subangular gravel and cobbles, slightly moist, very dense. | 52* | 4.5+* | 120.1 | 4.1 |
| 10 | 3, 4 | 3-3 | | Yellowish brown silty clayey fine SAND, rare fine subrounded gravel, slightly moist, dense. | 32* | 4.5+* | 104.8 | 11.4 |
| 15 | 5 | 3-4 | | Yellowish brown with olive brown SAND with fine subrounded gravel, moist, very dense. | 38*/4" | | | |
| | | 3-5 | | | 67 | | | |
| 20, 25, 30 | 6, 7, 8, 9 | | | Bottom of boring at approximately 18 feet.<br>Ground water not encountered. | | | | |

ENGEO
INCORPORATED

PITTSBURG 6 MG
WATER STORAGE RESERVOIR PROJECT
PITTSBURG, CALIFORNIA

BORING NO.: B3

DATE: January 1998

PROJECT NO.: 2494-M2

CHECKED BY JM

FIGURE NO. 7

Reference: Boring No. 3 - Geotechnical Exploration for City of Pittsburg 6 MG Water Storage Reservoir Project (ENGEO, December 1997)

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File No. 5003.0

June 2013

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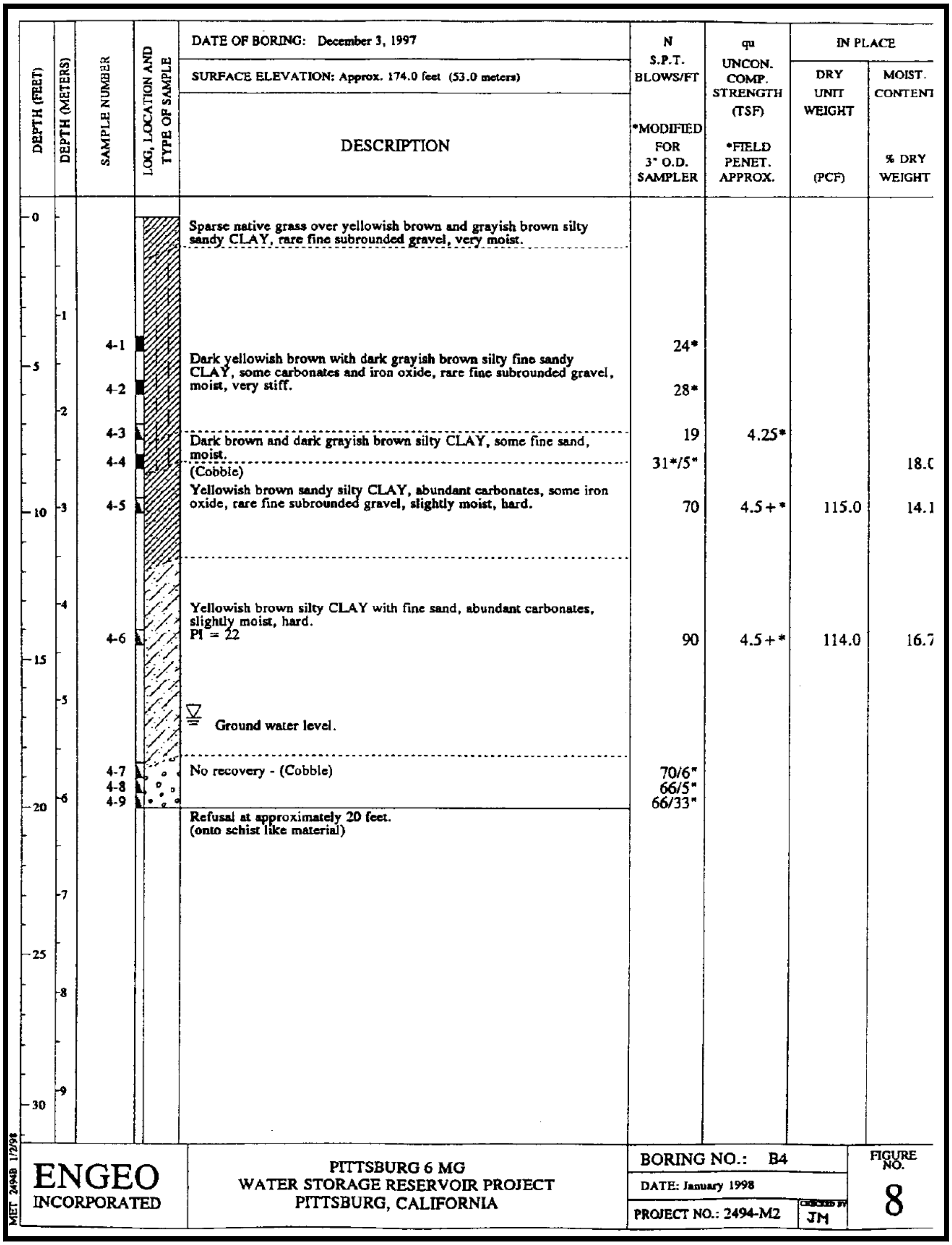
Water Treatment Plant Capital Improvements Project
Pittsburg, California

## Log of Reference Boring RB-11

Figure
**D-12**



DATE OF BORING: December 3, 1997

SURFACE ELEVATION: Approx. 174.0 feet (53.0 meters)

| DEPTH (FEET) | DEPTH (METERS) | SAMPLE NUMBER | LOG, LOCATION AND TYPE OF SAMPLE | DESCRIPTION | N S.P.T. BLOWS/FT *MODIFIED FOR 3" O.D. SAMPLER | qu UNCON. COMP. STRENGTH (TSF) *FIELD PENET. APPROX. | IN PLACE DRY UNIT WEIGHT (PCF) | IN PLACE MOIST. CONTEN % DRY WEIGHT |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | Sparse native grass over yellowish brown and grayish brown silty sandy CLAY, rare fine subrounded gravel, very moist. | | | | |
| | 1 | | | | | | | |
| | | 4-1 | | Dark yellowish brown with dark grayish brown silty fine sandy CLAY, some carbonates and iron oxide, rare fine subrounded gravel, moist, very stiff. | 24* | | | |
| 5 | | | | | | | | |
| | | 4-2 | | | 28* | | | |
| | 2 | | | | | | | |
| | | 4-3 | | Dark brown and dark grayish brown silty CLAY, some fine sand, moist. | 19 | 4.25* | | |
| | | 4-4 | | (Cobble) | 31*/5" | | | 18. |
| 10 | 3 | 4-5 | | Yellowish brown sandy silty CLAY, abundant carbonates, some iron oxide, rare fine subrounded gravel, slightly moist, hard. | 70 | 4.5+* | 115.0 | 14.1 |
| | 4 | | | Yellowish brown silty CLAY with fine sand, abundant carbonates, slightly moist, hard.<br>PI = 22 | | | | |
| | | 4-6 | | | 90 | 4.5+* | 114.0 | 16.7 |
| 15 | | | | | | | | |
| | 5 | | | ▽ Ground water level. | | | | |
| | | 4-7 | | No recovery - (Cobble) | 70/6" | | | |
| | | 4-8 | | | 66/5" | | | |
| 20 | 6 | 4-9 | | | 66/33" | | | |
| | | | | Refusal at approximately 20 feet.<br>(onto schist like material) | | | | |
| | 7 | | | | | | | |
| 25 | | | | | | | | |
| | 8 | | | | | | | |
| | 9 | | | | | | | |
| 30 | | | | | | | | |

MET 2494B 1/2/98

**ENGEO**
INCORPORATED

PITTSBURG 6 MG
WATER STORAGE RESERVOIR PROJECT
PITTSBURG, CALIFORNIA

BORING NO.: B4
DATE: January 1998
PROJECT NO.: 2494-M2
CHECKED BY JM

FIGURE NO. 8

Reference: Boring No. 4 - Geotechnical Exploration for City of Pittsburg 6 MG Water Storage Reservoir Project (ENGEO, December 1997)

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File No. 5003.0

June 2013

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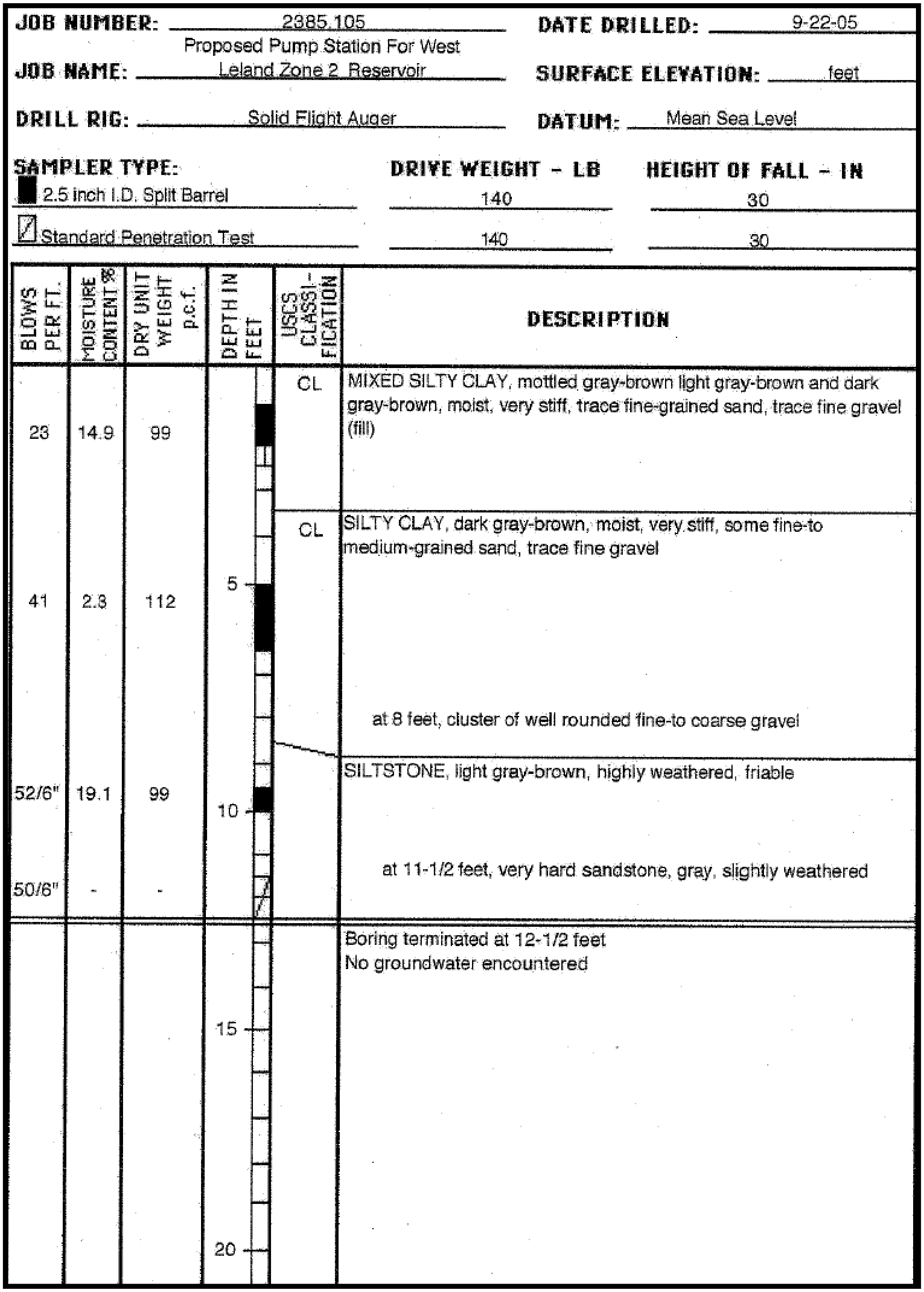
Pittsburg, California

## Log of Reference Boring RB-12

Figure

**D-13**



**JOB NUMBER:** 2385.105

**DATE DRILLED:** 9-22-05

**JOB NAME:** Proposed Pump Station For West Leland Zone 2 Reservoir

**SURFACE ELEVATION:** feet

**DRILL RIG:** Solid Flight Auger

**DATUM:** Mean Sea Level

| SAMPLER TYPE: | DRIVE WEIGHT - LB | HEIGHT OF FALL - IN |
|---|---|---|
| ■ 2.5 inch I.D. Split Barrel | 140 | 30 |
| ▨ Standard Penetration Test | 140 | 30 |

| BLOWS PER FT. | MOISTURE CONTENT % | DRY UNIT WEIGHT p.c.f. | DEPTH IN FEET | USCS CLASSI-FICATION | DESCRIPTION |
|---|---|---|---|---|---|
| | | | | CL | MIXED SILTY CLAY, mottled gray-brown light gray-brown and dark gray-brown, moist, very stiff, trace fine-grained sand, trace fine gravel (fill) |
| 23 | 14.9 | 99 | | | |
| | | | | CL | SILTY CLAY, dark gray-brown, moist, very stiff, some fine-to medium-grained sand, trace fine gravel |
| 41 | 2.3 | 112 | 5 | | |
| | | | | | at 8 feet, cluster of well rounded fine-to coarse gravel |
| | | | | | SILTSTONE, light gray-brown, highly weathered, friable |
| 52/6" | 19.1 | 99 | 10 | | |
| 50/6" | - | - | | | at 11-1/2 feet, very hard sandstone, gray, slightly weathered |
| | | | | | Boring terminated at 12-1/2 feet<br>No groundwater encountered |
| | | | 15 | | |
| | | | 20 | | |

Reference: Boring P-1 (Berloger Geotechnical Consultants, September 2005)

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June 2013

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Water Treatment Plant Capital Improvements Project
Pittsburg, California

## Log of Reference Boring RB-13

**Figure**

**D-14**

**JOB NUMBER:** 2385.105

**DATE DRILLED:** 9-22-05

**JOB NAME:** Proposed Pump Station For West Leland Zone 2 Reservoir

**SURFACE ELEVATION:** feet

**DRILL RIG:** Solid Flight Auger

**DATUM:** Mean Sea Level

| SAMPLER TYPE: | DRIVE WEIGHT - LB | HEIGHT OF FALL - IN |
|---|---|---|
| ■ 2.5 inch I.D. Split Barrel | 140 | 30 |

| BLOWS PER FT. | MOISTURE CONTENT % | DRY UNIT WEIGHT p.c.f. | DEPTH IN FEET | USCS CLASSI-FICATION | DESCRIPTION |
|---|---|---|---|---|---|
| | | | | CL | SANDY CLAY, gray-brown, moist, hard, fine-to medium-grained sand, trace fine-gravel (fill) |
| 60 | 10.0 | 98 | | | |
| | | | | | below 4 feet, light orange-brown sandstone fragments mixed in |
| | | | | | below 5 feet, dark gray-brown |
| 51 | 11.0 | 87 | 5 | | |
| | | | | CL | SILTY CLAY, dark gray-brown, moist, hard, some fine-grained sand, trace fine gravel |
| 50/6" | 14.4 | 106 | | | |
| | | | | CL | SANDY CLAY ( CLAYSTONE/SILTSTONE highly weathered bedrock), light gray-brown, moist, hard, fine-grained sand, trace well rounded fine gravel, some silt |
| | | | 10 | | |
| | | | | | below 13 feet, fine-to coarse-grained sand, caliche veins |
| 50/6" | 15.5 | 102 | | | |
| | | | 15 | | |
| | | | | | at 17 feet, layer of well rounded fine-to coarse gravel |
| 60/6" | 18.7 | 106 | | | |
| | | | 20 | | |

Reference: Boring P-2, 1 of 2 (Berloger Geotechnical Consultants, September 2005)

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Pittsburg, California

## Log of Reference Boring RB-14

Figure

**D-15**

(1 of 2)

**JOB NUMBER:** 2385.105

**SHEET:** 2 **OF:** 2

**JOB NAME:** Proposed Pump Station For West Leland Zone 2 Reservoir

**DEPTH:** 20 feet **TO** 30 feet

**NOTES:**

| BLOWS PER FT. | MOISTURE CONTENT % | DRY UNIT WEIGHT p.c.f. | DEPTH IN FEET | USCS CLASSI-FICATION | DESCRIPTION |
|---|---|---|---|---|---|
| | | | | CL | SANDY CLAY ( CLAYSTONE/SILTSTONE highly weathered bedrock), light gray-brown, moist, hard, fine-grained sand, trace well rounded fine gravel, some silt |
| 50/6" | 17.9 | 102 | | | |
| | | | 25 | | |
| | | | | ML | CLAYEY SILT ( SILTSTONE highly weathered bedrock), light gray-brown, moist, hard, trace fine-grained sand and sandstone fragments |
| 50/6" | 18.7 | 105 | | | |
| | | | 30 | | Boring terminated at 30 feet<br>No groundwater encountered |
| | | | 35 | | |
| | | | 40 | | |

Reference: Boring P-2, 2 of 2 (Berloger Geotechnical Consultants, September 2005)

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Pittsburg, California

## Log of Reference Boring RB-14

Figure

**D-15**

(2 of 2)