REPORT

GEOTECHNICAL INVESTIGATION
BANK 82 ADDITION, 2ND 500 KV TIE LINE,
AND NEW 230 KV YARD
IMPERIAL VALLEY SUBSTATION
IMPERIAL COUNTY, CALIFORNIA

PREPARED FOR:

SAN DIEGO GAS & ELECTRIC

URS PROJECT NO. 27668011.00010

JUNE 10, 2009

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GEOTECHNICAL INVESTIGATION BANK 82 ADDITION, 2ND 500 KV TIE LINE, AND NEW 230 KV YARD IMPERIAL VALLEY SUBSTATION IMPERIAL COUNTY, CALIFORNIA

Prepared for

San Diego Gas & Electric Company
8316 Century Park Court, CP-52G
San Diego, California, 92123

URS Project No. 27668011.00010

June 10, 2009

URS

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June 10, 2009

Mr. Ron Brunton
San Diego Gas & Electric Company
8316 Century Park Court, CP-52G
San Diego, California, 92123

Subject: Geotechnical Investigation
Bank 82 Addition, 2nd 500 kV Tie Line, and New 230 kV Yard
Imperial Valley Substation
Imperial County, California
URS Project No. 27668011.00010

Dear Mr. Brunton:

URS Corporation Americas (URS) is pleased to submit the following report presenting the results of our geotechnical investigation for the proposed improvements at the existing San Diego Gas & Electric Company Imperial Valley Substation. This investigation was performed in general accordance with our proposal dated May 27, 2008 and our Standard Service Agreement Nos. 5660004780 and 6160015090.

This report presents the results of our investigation and geotechnical recommendations for design. The results of the study indicate that the site is suitable for the proposed development, provided that the geotechnical and geologic considerations discussed in this report are incorporated into the design.

We are pleased to be part of this important project, and if you have any questions, please contact us at (619) 294-9400.

Sincerely,

URS CORPORATION

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JLN/MEH:kl

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ASTM	American Society for Testing and Materials
Benton	Benton Engineering Inc.
bgs	below ground surface
Cal OSHA	California Occupational Safety and Health Administration
Caltrans	State of California Department of Transportation
CBC	California Building Code
CBR	California Bearing Ratio
EI	Expansion Index
E_{pmt}	Pressuremeter Modulus
EPRI	Electric Power Research Institute
ft	feet
Fugro	Fugro, Inc.
g	units of gravity
IBC	International Building Code
IEEE	Institute of Electrical and Electronics Engineers, Inc.
in	inches
kips	kilopounds
ksi	kips per square inch
kV	Kilovolt
MCE	Maximum Considered Earthquake
MFAD	Moment Foundation Analysis and Design
MSL	Mean Sea Level
N	Blowcount
ohm-cm	Ohm-centimeters
pcf	pounds per cubic foot
PGA	peak ground acceleration
psf	pounds per square foot
R-Value	Resistance Value (for pavement design)
SDG&E	San Diego Gas & Electric Company
SPT	Standard Penetration Test
Substation	Imperial Valley Substation
TI	Traffic Index
URS	URS Corporation Americas
USCS	Unified Soil Classification System
USGS	United States Geological Survey

SECTION 1 INTRODUCTION

This report presents the results of URS Corporation Americas' (URS) geotechnical investigation for the proposed improvements at the existing San Diego Gas & Electric Company (SDG&E) Imperial Valley Substation (Substation) located in Imperial County near El Centro, California. The Substation is located south of Interstate 8 and north of State Route 98, just west of the Westside Main Canal (Figure 1). URS prepared this report for SDG&E and their consultants for use in project planning and design.

1.1 PROJECT DESCRIPTION

The currently planned additions are on the west side of the Substation and include the Bank 82 Addition, a 2nd 500 kilovolt (kV) Tie Line and a new 230 kV Yard. An area is also available at the southwest corner of the site for the terminus of the proposed Sunrise Powerlink Transmission Line. Figure 2 presents a site plan with the current Substation layout and the approximate locations of the proposed additions. Elements of the additions include switch stands, circuit breakers, transformers, firewalls, "A" frames, "H" frames, and bus supports. Foundation types for this equipment typically include drilled piers, shallow strip foundations and mat foundations. Final foundation layouts and structural loads are not available at this time. Preliminary foundation information for the Bank 82 Addition is summarized below based on existing and similar designs at the Imperial Valley Substation. The information was provided by Mr. Ron Brunton via email on June 16, 2008 and in subsequent discussions. Safety factors of 1.5 to 2.0 are incorporated in the loads shown.

Shallow Foundations

Structure	Foundation Thickness (in)	Foundation Plan Area	Vertical Load (kips)	Maximum Soil Pressure Due to Seismic Overturning (psf)
Disconnect Switch Stand	18	13'-0" x 22'-6"	14	500 to 1,000
Circuit Breaker	18	9'-6" x 12'-0"	17	1,500 to 2,000
Transformer Mat	36	16'-0"x 34'-0"	862	3,760

Deep Foundations

Structure	Planned Pier Diameter (in)	Planned Pier Length (ft)	Vertical Load (kips)	Lateral Load (kips)	Moment (ft-kips)
Firewall Support Piers	66	26.5	60	125	1,800
60' Dead End A-Frame	60 to 66	18 to 24	150 downward 110 uplift	60	400
Single Column Bus Support	30	6 to 8	1	6	40
SL&P Rack Support Steel	36	8 to 10	6	12	140
38' Dead End H-Frame	48 to 60	14 to 16	20	12	40 to 60

In addition to specific recommendations for the planned improvements, we understand that SDG&E desires general foundation design information for the entire Substation to accommodate future additions not yet planned.

1.2 PURPOSE AND SCOPE OF INVESTIGATION

The purpose of our services was to explore subsurface conditions at the substation and provide geotechnical recommendations for design and construction. The scope of our investigation included a review of the area geology and available previous investigations at the Substation, field explorations, pressuremeter testing, geotechnical laboratory testing, engineering analyses and evaluations, and development of design recommendations. Our scope of services was expanded from addressing only the currently planned additions to include an evaluation of the full Substation area based on available information.

The results of the investigation were used to develop geotechnical recommendations regarding:

- General subsurface soil and groundwater conditions;
- Geologic setting and assessment of geologic and seismic hazards including surface faulting, strong ground motion, liquefaction, and seismic settlement;
- Presence and effect of near-surface expansive and collapsible soils;
- Earthwork recommendations;
- Appropriate foundation types;
- Allowable vertical and lateral capacities of shallow foundations;
- Modulus of subgrade reaction for mat foundations;
- Estimated total and differential shallow foundation settlements;
- Allowable axial capacities of deep foundations;
- Parameters for lateral deep foundation design;
- Surface drainage;
- Flexible pavement design;
- Corrosion potential of soil;
- Substation equipment seismic qualification level; and
- Construction considerations.

Detailed results of previous information, current field exploration, pressuremeter testing, and geotechnical laboratory testing are provided in the appendices of this report.

SECTION 2 GEOTECHNICAL INVESTIGATION

The geotechnical investigation included a review of previous studies and available information, a site reconnaissance, geotechnical borings, pressuremeter testing, and laboratory testing.

2.1 PREVIOUS STUDIES

URS previously performed geotechnical investigations for improvements at the Substation, 1) for the access road from State Route 98, and 2) for associated transmission line structures. URS has also been provided with copies of previous investigations by others at and near the site. A detailed list of references is provided in Section 6. The investigations within the Substation are summarized below. The approximate locations of the explorations from these previous studies are presented on Figure 2. Geotechnical information from these investigations were evaluated and the data was incorporated into our current investigation where appropriate. Copies of the boring logs and selected geotechnical laboratory test results from these investigations are presented in Appendix A.

2.1.1 Fugro, 1980

Fugro, Inc. (Fugro) performed the feasibility and preliminary geotechnical investigation for construction of the Substation. The investigation included four hollow stem auger borings advanced to depths up to about 52 feet below grade. Representative soil samples were tested for grain size distribution. The ground surface elevations from the Fugro borings are inconsistent with the historical topographic elevations at the site. For the current study, the ground surface elevations at the Fugro borings have been approximated based on historical topographic information from the Substation construction.

2.1.2 Benton, 1980

Benton Engineering Inc. (Benton) performed the design level geotechnical investigation for the Substation. The investigation included twenty-one borings advanced to depths between about 12 and 50 feet below grade. Twenty of the borings were rotary wash and one of the borings (Boring 21) was a large diameter (30-inch) bucket-type boring. The geotechnical laboratory test program included shear strength, consolidation, expansion, California Bearing Ratio (CBR), unconfined compressive strength, and chemical analysis for corrosion potential.

2.1.3 URS, 2003

URS performed a geotechnical investigation for new transformers and firewalls and a retrofit of existing firewall structures. Three hollow stem auger borings were advanced in the central portion of the Substation to depths of up to 37 feet below grade. Laboratory testing included unconfined compression, particle size distribution, and laboratory compaction tests.

2.2 SUBSURFACE EXPLORATIONS

The current field investigation included a visual reconnaissance of the existing surface conditions and drilling and logging eight test borings in the western half of the Substation. The borings were designated

Boring B-1 through Boring B-8 and their approximate locations are shown on Figure 2. Boring B-1 and Boring B-2 were advanced in the area of the new 230 kV yard. Boring B-3 and Boring B-4 were advanced in the area of the Bank 82 Addition. Boring B-5 and Boring B-6 were advanced in the area of the 2nd 500 kV Tie Line. Boring B-7 and Boring B-8 were advanced where future transmission line improvements are being considered. The geotechnical borings were advanced using a truck mounted drill rig with hollow-stem augers. The borings were advanced to depths of 51.5 feet below the ground surface (bgs). Additional borings were advanced immediately adjacent to Borings B-3, B-6, and B-7 using mud rotary drilling for pressuremeter testing. The subsurface investigation was performed between June 2 and 9, 2008.

An engineering geologist from our firm logged the borings, and the soil encountered was classified in general accordance with the Unified Soil Classification System (USCS). Disturbed and relatively undisturbed soil samples were collected from the borings. A Key to Logs is presented in Appendix B as Figure B-1. Logs of the borings are presented in Appendix B in Figures B-2 through Figure B-9. Further details of the field exploration are presented in Appendix B.

2.3 PRESSUREMETER TESTING

A total of 18 pressuremeter tests were performed in borings immediately adjacent to Boring B-3, Boring B-6, and Boring B-7 to provide the basis of design values of the pressuremeter modulus (E_{pmt}) used for lateral deep foundation design. The specific locations and depths for the pressuremeter tests were selected after a review of the subsurface conditions encountered in the hollow-stem auger borings to provide data in a variety of strata within the expected foundation depths.

The pressuremeter testing is the start of a regional effort to collect pressuremeter modulus data for the various formations and deposits present in the SDG&E service area. The methodology and results of the pressuremeter testing are summarized in Appendix C.

2.4 LABORATORY TESTING

The materials encountered in the field were visually classified and evaluated with respect to consistency, density, and moisture content. The samples were then returned to our laboratory for further examination and testing. Grain size and plasticity analyses on representative samples of the soils substantiated the visual classifications. The strength and compressibility of the soil were evaluated by considering the density and moisture content of relatively undisturbed samples, results of direct shear tests and unconsolidated undrained triaxial tests, and by other empirical correlations between soil characteristics and physical properties. A laboratory compaction test was performed on a sample of near surface soil to evaluate the moisture density relationship. Resistivity, sulfate content, pH, and chloride content tests were performed to evaluate the potential corrosivity of the soils. Testing was performed in general accordance with applicable American Society for Testing and Materials (ASTM) standards. Results of laboratory testing are shown at the corresponding sample locations on the boring logs in Appendix B; detailed results are presented in Appendix D.

SECTION 3 SITE CONDITIONS

Knowledge of the site conditions was developed from a review of available information, site reconnaissance and the current investigation.

3.1 GEOLOGIC SETTING

The site is in the Imperial Valley, which is part of the Salton Trough physiographic province. The Salton Trough is bounded by the Western Mojave Desert, the Peninsular Ranges Batholith, the Basin and Ranges and the Gulf of California. The Salton Trough is a deep, structural basin characterized by high seismicity, high heat flux, extensional tectonics, crustal thinning, and rapid sedimentation (Damiata *et al.,* 1986). Geophysical studies (Tarbet 1951; Biehler *et al.*, 1964) suggest that upwards of 5.5 kilometers (3.3 miles) of sediment have accumulated in the Salton Trough since the Miocene epoch (Eberley and Standley 1978).

The Salton Trough represents the transition zone between the crustal spreading centers in the Gulf and the right-lateral transform boundary between the North America and Pacific plates (Crowell and Sylvester 1979; Crowell 1981). The San Andreas fault zone is the principal element in this transform plate boundary; however, the total plate motion is distributed across a broad zone of deformation. Major elements in the right-slip system of faults related to the plate boundary and near the Salton Trough include the San Andreas, San Jacinto, Elsinore-Laguna Salada, Brawley, Imperial, and Cerro Prieto faults. Figure 3 presents a regional geologic map.

3.2 TECTONIC SETTING

The tectonic setting of the Imperial Valley is influenced by plate boundary interaction between the Pacific and North American lithospheric plates. This crustal interaction occurs along a broad belt of northwest-trending, predominately right-slip faults that span the width of the Peninsular Ranges and extend into the offshore Continental Borderland province. The major southern California fault systems include the San Andreas, San Jacinto, and Imperial fault zones to the east; the San Clemente, Coronado Bank, San Jacinto, Elsinore and Rose Canyon fault zones to the west; and the Agua Blanca and San Miguel fault zones to the southwest.

3.3 LOCAL FAULTS

The Imperial Valley is historically an area of high seismic activity and it is characterized by numerous active faults as shown on Figure 4, a regional fault and epicenter map. High-activity faults in the Imperial Valley include the San Andreas, Imperial, and San Jacinto faults.

Active faults within 25 kilometers of the site include: the Laguna Salada-Elsinore, San Jacinto, Imperial, and Yuha Wells faults. The Laguna Salada-Elsinore fault zone and the San Jacinto fault zone lie west and north of the site at distances of 14 and 20 kilometers, respectively.

The Imperial fault is 23 kilometers east of the site and is characterized by a high rate of slip estimated at 20 millimeters per year. The Imperial fault has ruptured the ground surface twice historically, once in 1940 and again in 1979.

The Yuha Wells fault is approximately 10 kilometers northwest of the site. This secondary fault is considered active although it has not been extensively studied. It is a northeasterly striking, left-lateral fault and is thought capable of generating earthquakes of approximately magnitude 6. The importance of left-lateral faults in the Imperial Valley was brought to light in 1987 when the left-lateral Elmore Ranch fault generated a magnitude 6.2 event that then triggered a magnitude 6.6 event on the adjacent branch of the San Jacinto fault. The Yuha Wells fault appears to be a similar cross fault structure.

3.4 SURFACE CONDITIONS

The Imperial Valley Substation site has been graded and developed and is relatively flat. Elevations across the site range from approximately +3.0 to +10.5 feet Mean Sea Level (MSL) based on grading plans from the original Substation construction. SDG&E also provided surveyed ground surface elevation information at each boring location; this information is presented on the boring logs.

The Substation is in an area of undeveloped low-lying desert with sparse vegetation. A gravel access road leads to the Substation from the south, approaching the west side of the Substation. The Westside Main Canal runs generally north-south and is located east of the Substation. Drainage within the general area typically flows in a northeasterly to easterly direction. Prior to construction, the site drained to the northeast. Currently, the site drains to the east and northeast.

3.5 SUBSURFACE CONDITIONS

This section describes the subsurface conditions at the site as encountered in our recent geotechnical borings and previous geotechnical borings by URS and by others. These explorations indicate that a minor veneer of fill typically overlies interbedded alluvial and lacustrine deposits at the site. These units are described in the following paragraphs, and are described in more detail on the boring logs in Appendix A and Appendix B. Figures 5 and 6 present generalized geologic cross sections through the Substation. The locations of the cross sections are shown on Figure 2.

3.5.1 Fill

In general, it appears the previous site development involved little grading. A plan from the original construction of the Substation shows cuts on the order of 2 feet in the southwestern corner and fills on the order of 2 to 5 feet in the northwest corner of the Substation. Typical SDG&E Substation design also includes a 1-foot thick wearing surface.

The URS 2003 investigation reported fill approximately 1.5 to 2 feet deep in three explorations in the center of the Substation. The fill was described as sandy gravel and is likely a wearing surface constructed for the Substation. Fill thicknesses were not identified during the recent investigation.

3.5.2 Alluvial and Lacustrine Deposits

The borings at the Substation encountered alluvial and lacustrine deposits. Alluvium deposition resulted from valley fill or distal fan processes. Lacustrine deposits are associated with the ancient Lake Cahuilla. These deposits are layered and interfingered, consisting of alternating layers of clean sand, silty and clayey sand, silt, lean clay, and fat clay. The blowcounts in these materials indicate medium dense to dense sands and stiff to hard silts and clays. For simplicity, we have categorized the subsurface materials into 1) granular alluvial deposits and 2) fine-grained lacustrine deposits.

The cross sections presented on Figures 5 and 6 suggest that alluvial deposits predominate on the south side of the Substation and lacustrine deposits predominate on the north side. However, significant interlayering is present and subsurface conditions vary significantly, even between adjacent borings. Hence, different areas of the site require separate characterization and engineering evaluation.

3.6 GROUNDWATER

Groundwater was encountered at a depth of approximately 35 to 36 feet below existing grade in Borings B-7 and B-8 at the time of the field investigation in June 2008. A temporary piezometer was placed in Boring B-8 and the water level was recorded one day after drilling. Although direct observation of groundwater was not observed in the remaining borings, wet soil conditions were observed at similar depths. Groundwater was observed at the time of drilling in Boring B-3 of the URS 2003 investigation at a depth of 34 feet bgs.

SECTION 4 DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

The discussions, conclusions, and recommendations presented in this report are based on information provided to us, review of available information, results of our field investigation, pressuremeter testing, laboratory testing, empirical correlations, engineering and geologic analyses, and professional judgment.

4.1 GEOLOGIC HAZARDS

4.1.1 Surface Faulting Hazard

Based on a review of previous investigations, published and unpublished mapping and an analysis of historic stereographic aerial photographs, surface faulting is not considered a significant hazard at the site.

4.1.2 Seismic Coefficients

Seismic coefficients have been developed in accordance with the seismic criteria provided in the 2007 California Building Code (CBC). Based on the site location and site conditions described in Section 3, the values listed in Table 1 should be used for design.

4.1.3 Liquefaction and Seismic Compaction

Seismically induced liquefaction is a phenomenon in which loose, saturated, nonplastic (typically granular) materials develop high pore water pressure and lose strength because of ground vibrations induced by earthquakes.

The site specific subsurface information gathered as part of this geotechnical investigation and for previous investigations at the Substation typically demonstrates a low liquefaction potential for the site. The groundwater surface is estimated at a depth of approximately 36 feet below the site, so the upper sands are not saturated. Below groundwater, the materials encountered in the majority of our borings to the depths explored (51.5 feet) are typically fine grained and not considered susceptible to liquefaction. Liquefaction is typically limited to within 50 feet of the ground surface.

A two to four foot thick layer of potentially liquefiable material was encountered at a depth of about 35 feet bgs in Borings B-7 and B-8 and was also observed just below groundwater in Fugro Boring B-3. This potential for liquefaction should be considered as part of foundation design for the future transmission line or other foundations in Zone A (see Figure 2) of the Substation. Liquefaction-induced settlement is estimated to be on the order of one inch in this area.

Seismic compaction occurs in loose to medium dense dry sandy materials above groundwater due to particle rearrangement during seismic shaking. The magnitude of seismic compaction at the Substation is estimated to be on the order of 1 inch or less for the soil profile variability and the range of ground motions anticipated at the site. The higher seismic settlements are expected to be on the south side of the site where coarse-grained alluvial material dominates the near-surface.

4.1.4 Expansion and Collapse Potential

Fine-grained soils with expansion potential are present in the near surface in many areas of the site. The occurrence of clayey soils is greater in the northern half of the site.

Benton considered the clay, sandy clay, and silty clay encountered at the site to have high potential for expansion and the silt and sandy silt to be non expansive to slightly expansive. For the construction of the Substation, they recommended that the northerly half of the site be capped with at least 3 feet of nonexpansive soil. Borings B-1 through B-4 performed for this investigation in the northern portion of the site demonstrated granular (non expansive) materials in the near surface. One Expansion Index (EI) test, performed on a sample from the recently excavated Bank 82 mat foundation subgrade indicated a low expansion potential.

Loosely deposited alluvium can be subject to collapse due to wetting and/or inundation. Collapse can occur in dry soils that have an unstable soil structure due to deposition or irrigation processes, typically with a skeletal structure that is weakly cemented by soluble salts or clay. Increases in moisture content can cause the interparticle cementation to reduce, causing changes in volume (collapse), especially when loaded. The Substation site is developed and graded to drain to prevent inundation. In addition, the existing site has been subject to storms since the original construction, and is not likely to experience additional collapse settlement. Therefore, the potential for collapse settlement to affect the planned improvements is low.

Given the variable nature of materials across the site, expansion and collapse potential should be evaluated on a foundation specific basis. Mitigation of expansion and collapse potential can be performed by selective earthwork practices during construction if needed.

4.1.5 Other Hazards

The local geologic conditions indicate that the probability of other geologic hazards (such as slope instability, subsidence, seiches, tsunamis, and flooding) affecting the site is very low. There are no significant slopes near the project; therefore, slope instability is not considered a hazard. The potential for seiches or tsunamis to affect the site is considered low given the site location. Similarly, the site is not in an active flood plain and the risk from flooding is considered low. Land subsidence resulting from fluid withdrawal is not currently occurring in the site vicinity and is not a hazard at the site. These hazards do not constitute constraints to site development.

4.2 EARTHWORK

4.2.1 General

Site earthwork will generally consist of removal of unsuitable (loose, soft, expansive or collapsible) material, foundation excavations, and backfills of utility trenches. Earthwork should be performed in accordance with SDG&E requirements and the latest edition of the Standard Specifications for Public Works Construction (“Green Book”). A preconstruction conference should be held at the site with the owner, contractor, civil engineer, and geotechnical engineer in attendance.

4.2.2 Site Clearing and Demolition

Any vegetation and construction debris within areas that are to be improved should be cleared and properly disposed of off-site. Roots and other vegetative matter, if encountered, should be removed and disposed of off-site.

Existing infrastructure within areas that are to be improved should be properly demolished and disposed of at an appropriate facility off-site. Existing utilities may be abandoned by backfilling with sand-cement slurry, subject to approval by the Geotechnical Engineer.

4.2.3 Subgrade Preparation

Foundation and slab-on-grade subgrades should be inspected by a representative of the Geotechnical Engineer to observe and document the absence of loose, soft, potentially expansive, or collapsible soils. If expansive soils are encountered at the foundation level, the potentially expansive material should be removed and replaced with nonexpansive material as directed by the Geotechnical Engineer. If collapsible soils are encountered at the foundation level, they should be prewetted to initiate collapse prior to the construction of the foundation, as directed by the Geotechnical Engineer.

The surface within areas to receive fill should be scarified, moisture conditioned as necessary, and compacted prior to fill placement. Areas temporarily vacated during earthwork should be similarly scarified, moisture conditioned and reworked to the satisfaction of a Geotechnical Engineer before placing additional fill to avoid drying and lamination along the fill interface.

Demolition excavations should be backfilled and compacted with suitable material. Each lift of fill should be benched into competent material to the satisfaction of the Geotechnical Engineer. The minimum width and height of the bench should not be less than the lift thickness. Likewise, contiguous areas that have been disturbed by demolition should be removed to the satisfaction of the Geotechnical Engineer and replaced with engineered fill.

4.2.4 Fill Materials

In our opinion, based on the laboratory testing completed for this study, the granular alluvial materials should be suitable for Common Fill and Select Fill as defined by SDG&E. Some of the clayey lacustrine materials demonstrated high plasticity characteristics and do not meet the requirements for Select Fill. If blended with nonplastic granular materials, the clayey materials would likely meet the requirements of Common Fill and may meet the requirements of Select Fill. Blending operations would require selective stockpiling during grading. We also note that some of the insitu materials could be corrosive to metal based on the limited corrosion potential laboratory testing completed for this study.

The onsite materials are generally suitable for use as engineered fill. Perishable, spongy or other compressible material should not be used for engineered fill. The following material types are applicable to the project:

- Common Fill. This material should consist of native or import soils that are approved for use by the Geotechnical Engineer. These materials should generally be granular soils (less than 50%

passing the No. 200 sieve) that are not excessively plastic (plasticity index less than 40) and/or contain quantities of oversize material that could make compaction difficult. Rocks or hard lumps less than 6 inches in maximum dimension may be used, provided the distribution of rocks is satisfactory to the Geotechnical Engineer.

- Select Fill. This material may consist of on-site excavated soil or imported soils that are approved by the Geotechnical Engineer. The material should not contain rocks or hard lumps greater than 3 inches in maximum dimension and at least 40% of material should be smaller than ¼-inch in size. In addition, the material should have an Expansion Index of less than 50, a Liquid Limit (LL) less than 30 and a Plasticity Index (PI) less than or equal to 15.
- Class 2 Aggregate Base Material. Aggregate base material should conform to the State of California Department of Transportation (Caltrans) “Standard Specifications” Section 26-1.02A Class 2 Aggregate Base.

4.2.5 Fill Placement and Compaction

Fill material should be placed in loose lifts no thicker than 8 inches, moisture conditioned, and processed as necessary to achieve uniform moisture content above optimum. Each lift should be compacted to not less than 90% relative compaction. Relative compaction is defined as the ratio of the in-place dry density to the maximum dry density determined using the latest version of ASTM D1557 as the compaction standard.

Class 2 aggregate base should be compacted to 95% of the maximum dry density as determined by ASTM D1557. Each lift should be compacted before the next lift is placed, except where specifically designated by the Geotechnical Engineer to facilitate mixing of materials.

4.3 SHALLOW FOUNDATIONS

Vault structures, transformers, switch stands, circuit breakers, control buildings, and other lightly loaded structures may be supported on conventional shallow spread and continuous footings or mat foundations.

4.3.1 Footing Dimensions and Embedment

The recommended minimum spread or strip footing embedment depth is 12 inches below finished grade. The recommended minimum spread or continuous foundations width is 12 inches. The recommended minimum mat foundation width is 5 feet. The Structural Engineer should determine the footing embedment, size and reinforcement based on anticipated loads and estimated differential settlements. Adjacent footings founded at different elevations should be located such that the slope from bearing level to bearing level is flatter than 1:1 (horizontal:vertical).

4.3.2 Allowable Foundation Pressure

Shallow foundations consisting of continuous and isolated spread footings or mat foundations bearing on engineered fill, alluvial, or lacustrine deposits may be designed using an allowable bearing pressure of 1,500 pounds per square foot (psf). For footings deeper or wider than 12 inches, the allowable bearing pressure may be increased by 500 psf for each additional 12 inches of depth, or by 1,000 psf for each additional 12 inches of width, up a maximum of 4,000 psf. Allowable bearing pressures may be increased by 33 percent for short term wind or seismic loads.

4.3.3 Allowable Lateral Bearing

Resistance to lateral loads on the shallow foundations may be provided by passive resistance along the outside face of footings and frictional resistance along the bottom of the footings. The allowable passive resistance may be taken as equivalent to a fluid weighing 250 pounds per cubic foot (pcf) for footings poured neat against engineered fill or native alluvial or lacustrine deposits.

An allowable friction coefficient of 0.35 may be used with the dead load to compute the frictional resistance of footings. If frictional and passive resistance is combined, the allowable friction coefficient should be reduced to 0.3.

The upper 12 inches of soil should be neglected in passive pressure calculations in areas where there will be no hardscape that extends from the outside edge of the footing to a horizontal distance equal to three times the footing depth. The resistance from passive pressure should be neglected where utilities or similar excavations may occur in the future.

4.3.4 Settlement

The settlement of a shallow foundation for a given allowable bearing pressure will depend upon the size, shape, embedment depth of the foundation, the relative compaction and stiffness of the fill or the relative density of underlying native materials, in addition to other factors.

A total settlement of less than one inch has been estimated for isolated spread and strip foundations designed with the minimum allowable vertical foundation pressures provided in this report and a minimum embedment depth of 12 inches. This settlement could increase by up to 50 percent if the design adopts the maximum allowable bearing pressure for increased embedment. This settlement estimate only considers dead loads. The maximum differential settlement between identical footings supporting similar loads should not exceed ½-inch, when only building loads are considered. The majority of the settlement due to building loads should occur during construction.

A total settlement of about 2 inches has been estimated for the static load and foundation size provided in Section 1.1 for the transformer mat foundations that are part of the Bank 82 Addition. Approximately half of the total should occur due to elastic settlement as the load is applied; the remaining settlement will result from consolidation of the clay below the groundwater level and is expected to be substantially complete within 2 to 6 months. Four mat foundations are planned, approximately 7.5 feet apart. Adjacent mat foundations will impose some additional stresses at depth below the edge of the mat under consideration; the additional consolidation settlement is estimated to be approximately ½-inch; however, it is expected that the stiffness of the mat should attenuate the majority of this additional settlement. Some additional minor settlement may occur upon the application of live loads.

Similar settlement may occur for other large mat foundations at the site. Actual settlement will depend upon the location on the site (due to varying subsurface conditions) and the foundation size and loading. Evaluation of individual mat foundations should be performed once this information is available.

If the estimated settlements cannot be tolerated by the structures, mitigation could include the following:

- Preloading the site using a surcharge fill or other load;
- Staging the construction to allow the majority of the settlement to occur prior to construction of critical elements;
- Supporting the mats on drilled piers or mini piles. Foundations would likely need to extend about 25 to 30 feet below the ground surface to reduce the elastic settlement and 40 to 50 feet deep to substantially reduce total settlement; and
- Improving the settlement properties of the underlying clay soil by soil improvement techniques such as deep soil mixing with the addition of lime or cement. Improvement depths would also likely need to extend 40 to 50 feet.

The structural or soil improvement methods are likely to be costly, although they could be performed relatively quickly if schedule is an issue. If scheduling and logistics permit, preloading and/or staging the construction is likely to be the most cost effective option. Settlement monitoring is recommended during preloading or staged construction.

4.3.5 Modulus of Subgrade Reaction

Deflections of mat foundations may also be estimated using the subgrade reaction (beam on elastic foundation) method of analysis. We recommend a modulus of subgrade reaction of 150 and 100 pounds per cubic inch for undisturbed granular alluvial or clayey lacustrine deposits, respectively.

4.4 DEEP FOUNDATIONS

Drilled pier foundations should have a minimum diameter of 2 feet and a minimum embedment of 6 feet below the ground surface. The base of the pier excavations should be free of any loose or disturbed materials.

The planned foundations are not anticipated to extend deeper than 30 feet below grade. If deeper foundations are planned in the future, URS should be contacted for further recommendations. In particular, the potential for liquefaction below 30 feet should be considered for foundation design in Zone A (Figure 2).

4.4.1 Pressuremeter Tests Results

As discussed previously, the pressuremeter testing performed for this project is the start of an effort to collect elastic pressuremeter modulus (E_{pmt}) data for the various formations and deposits present in the SDG&E service area. The E_{pmt} is a parameter required for the lateral pile design methodology used by SDG&E. Historically, correlations with SPT N value and soil properties have been used to estimate E_{pmt}, however, little field testing has been performed in the San Diego area to validate the parameters used for design. While field data can be technically applied only to the location of the test, these results and future pressuremeter test results provide a database of information that can be used to calibrate results for similar materials and to help estimate parameters where pressuremeter testing is not performed.

The pressuremeter testing at the Imperial Valley Substation was performed in Quaternary alluvial and lacustrine deposits of the Imperial Valley. The results of the testing are summarized in Table C-1 in Appendix C. The E_{pmt} in the clayey lacustrine deposits ranged between 1.5 and 2.2 kips per square inch (ksi), excluding the single highest and lowest values. The E_{pmt} in the alluviual sands and silty sands ranged between 1.2 and 1.6 ksi, excluding the single highest and lowest values. One test was performed in clayey sand, which resulted in an E_{pmt} of 1.9 ksi, intermediate between the clay and sand. Two tests were performed in silt, which can be a highly variable material, with results of 1.8 and 2.7 ksi. No substantive correlations of increasing E_{pmt} with increasing depth or density/stiffness were observed with the data.

Other than a few outliers, the measured E_{pmt} values were within a relatively narrow range for each material type, and are generally within the range that would be predicted using blowcount and other empirical correlations.

4.4.2 MFAD Design Parameters

We understand deep foundations at the site will be designed for lateral loads using the Electric Power Research Institute (EPRI) computer program, Moment Foundation Analysis and Design (MFAD). This program analyzes and designs drilled shaft foundations subject to high overturning moment loading. The design soil parameters required to use the MFAD program include:

- Soil Layer Depths
- Groundwater Depth
- Total Unit Weight
- Internal Friction Angle
- Cohesion
- Elastic Pressuremeter Modulus
- Strength Reduction Factor

Estimates of the required parameters were developed based on the results of our site observations, borings, laboratory testing, engineering evaluation and analysis, empirical correlation, literature research, and professional judgment. The estimated design parameters are presented in Table 2. Due to the variety of subsurface conditions, the Substation site was divided into Zones A through H, as shown on Figure 2, for the purpose of providing MFAD recommendations.

We recommend a design groundwater depth of 30 feet below the existing ground surface. The design does not need to discount surficial soils within the Substation; however, the upper 1 to 2 feet of soil should be discounted in design of pole foundations outside the Substation that may be subject to erosion. It should be noted that the design parameters presented in Table 2 are intended for use in the MFAD computer program and may not reflect actual strengths.

4.4.3 Allowable Skin Friction

Deep foundations at the site will also be designed to resist axial compression and uplift loads. The allowable skin friction on the sides of the drilled pier begins at grade and increases with depth as indicated on Figure 7 for downward loads and Figure 8 for uplift loads. The weight of concrete of the drilled pier was not included in our analyses but may be added to resist uplift. The allowable downward load can be increased by one third for loads that include wind or seismic forces.

4.4.4 Capacity Reduction for Group Effects

Construction of deep foundations in groups reduces the available capacity of drilled piers due to the relaxation of the soils within the adjacent foundation excavation. Design of piers spaced closer than 8 pier diameters on center can have total axial (downward and uplift) and lateral capacity less than the sum of the capacities of the individual piers.

A table of group efficiencies for piers founded in granular soils is presented in Table 3. The axial group efficiency effect can be incorporated by reducing the allowable skin friction and end bearing values to obtain the allowable axial capacities. The lateral group efficiency effect can be incorporated by magnifying the loads on the piers by the reciprocal of the efficiency.

For piers founded in clayey soils, group effects are generally less significant and the efficiency is evaluated based on the geometry of an equivalent pier having the shape of the outside boundary of the group. The piers for the Bank 82 firewalls (Zone C) are founded predominantly in clayey soils and spaced approximately 5 pier diameters apart. Based on our evaluation of the group block, no group capacity reduction is needed for these foundations.

4.5 SLABS-ON-GRADE

Slab-on-grade concrete floors for control buildings or similar facilities should be at least four inches thick. The Structural Engineer should design the thickness and reinforcement of concrete slab-on-grade floor slabs to accommodate concentrated loads and heavy distributed loads. Expansion joints and crack control sawcuts should be included at regular intervals.

4.6 SURFACE DRAINAGE

Positive measures should be taken to properly finish grade the area to direct drainage waters away from foundations and floor slabs. All runoff water should be directed to proper drainage areas and not be allowed to pond.

Even when these measures have been taken, experience has shown that a shallow groundwater or surface water condition can develop in areas where no such water condition existed prior to site development.

4.7 PAVEMENTS

The structural design of flexible pavement depends primarily on anticipated traffic conditions, subgrade soils, and construction materials. For preliminary evaluation purposes, we have adopted a Traffic Index

(TI) of 5.0. The traffic index should be confirmed prior to final design. We have assumed a Resistance-Value (R-value) of 35 as representative of the as-graded subgrade conditions consisting of non-expansive granular materials. Confirmation R-values test should be completed on samples obtained from the final subgrade materials where pavements are planned.

For preliminary design purposes, we recommend that the pavement structural section within the Substation consist of at least 3 inches of asphalt concrete over 5 inches of Class 2 Aggregate Base. The section assumes a properly prepared subgrade consisting of at least 12 inches of soil compacted to a minimum of 95% relative compaction. The aggregate base materials should be placed at a minimum relative compaction of 95%. Construction materials (asphalt and aggregate base) should conform to the current Standard Specifications for Public Works Construction.

4.8 CORROSION POTENTIAL

The results of pH, resistivity, and water-soluble sulfate and chloride tests are summarized in Table 4. It has been our experience with local corrosion engineers that resistivity results between 0 and 1,000 ohm-centimeters (ohm-cm) may be considered very corrosive and between 1,000 and 2,000 may be considered fairly corrosive to metallic utility piping and conduits. The corrosion testing performed by Benton for the construction of the Substation indicated severely corrosive materials are present on the site. A corrosion engineer should be consulted for additional design information.

The results of the testing indicate that the potential for chloride attack is low to moderate. The results of the tests indicated that sulfate attack to concrete may be considered negligible.

4.9 SUBSTATION EQUIPMENT SEISMIC QUALIFICATION LEVEL

The selection of the seismic qualification level for the performance evaluation of Substation equipment is based on IEEE Standard 693-2005. Following the seismic exposure map methodology presented in Section 8.6 of the IEEE Standard (IEEE 2005), a high qualification level is suggested based on a calculated peak ground acceleration of 0.57g. Table 5 presents the selected and calculated values following the procedures outlined in IEEE 693-2005 and based on the 2006 International Building Code (IBC) and the Maximum Considered Earthquake (MCE) ground motion presented on regional seismic hazard maps.

4.10 CONSTRUCTION CONSIDERATIONS

4.10.1 Excavation Characteristics

Trench excavation is expected to encounter little difficulty using modern trenching machines or backhoes, except where there are remnant obstructions associated with demolition. Conventional earth moving equipment (large diameter auger rigs, excavators, dozers, scrapers, etc.) should be able to excavate the soils encountered at the site with no unusual difficulty. Dry, cohesionless sands were observed in the borings. Vertical or steeply sloping excavations for trenches or drilled piers in cohesionless materials will not stand without predrilling stabilization, prewetting and/or casing or shoring.

4.10.2 Temporary Slopes

The design and excavation of temporary slopes as well as their maintenance during construction is the responsibility of the contractor. The contractor should have a geotechnical or geological professional evaluate the soil conditions encountered during excavation to determine permissible temporary slope inclinations and other measures as required by California OSHA (Cal OSHA).

Based on the existing data interpreted from the borings, the design of temporary slopes and benches for planning purposes may assume the conditions summarized in Table 6. The contractor's geotechnical or geological professional may use the information provided in this report to assess the stability of temporary slopes, as well as any additional data they may need to acquire, to prepare a specific temporary slope analysis and design. Existing infrastructure that is within a 2:1 (horizontal:vertical) line projected up from the toe of temporary slopes should be monitored during construction.

The contractor should note that the materials encountered in construction excavations may vary significantly across the site. The above assessment of soil type for temporary excavations is based on preliminary engineering classifications of material encountered in widely spaced explorations. The contractor's geotechnical or geological professional should observe and map mass excavations and temporary slopes at regular intervals during excavation and assess the stability of temporary slopes, as necessary.

4.10.3 Construction Observation and Testing

Earthwork and placement of engineered fill should be performed under the observation and testing services of a geotechnical professional supervised by a California–registered Geotechnical Engineer. Tests should be taken to determine the in-place moisture and relative compaction of engineered fill.

Removal excavations should be observed and mapped by a geologic or geotechnical professional during grading. All soils at foundation level should be observed by a geotechnical or geologic professional to observe that the subgrade is satisfactory. Excavations should be free of soft fill or loose and disturbed soils. The installation of drilled piers should also be observed.

A California-registered Geotechnical Engineer should prepare a final report of earthwork and foundation construction testing and observation at the completion of the project.

SECTION 5 LIMITATIONS

We have observed only a very small portion of the pertinent subsurface conditions. The recommendations made herein are based on the assumption that soil conditions do not deviate appreciably from those found during our field investigation. Specific details for may of the proposed projects are not available at this time. The recommendations presented in this report are intended to assist SDG&E and their consultants in the planning and design of the projects. The professional judgments and interpretations presented in this report are based on our current knowledge of the proposed improvements, our interpretations of the subsurface conditions in the project area, and our understanding of the geologic and tectonic setting of the project site. This knowledge is based on the information provided to us, published literature, previous studies by others, and our investigations.

We recommend that URS review the foundation plans for the currently proposed and future improvements to verify that the intent of the recommendations presented herein has been properly interpreted and incorporated into the contract documents. We further recommend that any site grading and earthwork, subgrade preparation under concrete slabs and paved areas, utility trench backfill, and foundation excavations be observed by a qualified engineer or geologist to verify that site conditions are as anticipated, or to provide revised recommendations, if necessary.

Geotechnical engineering and the geologic sciences are characterized by uncertainty. Professional judgments presented herein are based partly on our understanding of the proposed construction, and partly on our general experience. Our engineering work and judgments rendered meet current professional standards; we do not guarantee the performance of the project in any respect.

SECTION 6 REFERENCES

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Table 1
2007 CBC Seismic Coefficients
Imperial Valley Substation

Parameter	Value	2007 CBC Reference
Site Class	D	Table 1613.5.2
Mapped Spectral Acceleration - Short Period, S_s (g)	1.45	Figure 1613.5[1]
Mapped Spectral Acceleration - 1 Sec. Period, S_1 (g)	0.56	Figure 1613.5[1]
Site Coefficient - Short Period, F_a	1.0	Table 1613.5.3(1)[1]
Site Coefficient - 1 Sec. Period, F_v	1.5	Table 1613.5.3(2)[1]
MCE[2] Spectral Response Acceleration - Short Period, S_{MS} (g)	1.45	Equation 16-37, $S_{MS}=F_aS_S$
MCE[2] Spectral Response Acceleration - 1 Sec. Period, S_{M1} (g)	0.85	Equation 16-38, $S_{M1}=F_vS_1$
Design Spectral Response Acceleration - Short Period, S_{DS} (g)	0.96	Equation 16-39, $S_{DS}=2/3*S_{MS}$
Design Spectral Response Acceleration - 1 Sec. Period, S_{D1} (g)	0.56	Equation 16-40, $S_{D1}=2/3*S_{M1}$

Notes:
1. Calculated using USGS program "Earthquake Ground Motion Parameters" Version 5.0.8.
2. MCE – Maximum Considered Earthquake.
3. Site latitude and longitude obtained from Google Maps: 32.7181; -115.7156 for the center of the Substation.

Table 2
MFAD Design Parameters and Subsurface Characterization
Imperial Valley Substation

Depth Below Proposed Grade (feet)	Anticipated USCS Range	Total Unit Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)	E_{pmt} (ksi)	Shear Strength Reduction Factor, α
Zone A – Future Transmission Line						
0 to 8	SM, SP-SM, SP	110	33	0	1.5	1.0
8 to 13	CL	110	29	0	1.75	0.6
13 to 24	SM, SP-SM, SP	110	33	0	1.5	1.0
24 to 30	CL	110	29	0	1.75	0.6
Zone B – 2nd 500 kV Tie Line						
0 to 18	SM to SP-SM	110	33	0	1.5	1.0
18 to 30	CL	110	29	0	1.75	0.6
Zone C – Bank 82 Addition						
0 to 8	SC	110	33	0	1.5	1.0
8 to 14	CH	120	27	0	1.75	0.6
14 to 30	CL	110	29	0	1.75	0.6
Zone D – New 230 kV Yard						
0 to 8	SP to SP-SC	110	33	0	1.5	1.0
8 to 14	CH	120	27	0	1.75	0.6
14 to 30	CL	110	29	0	1.75	0.6

Notes:
1. The design groundwater level is 30 feet below existing grade.
2. No discount depth is recommended for deep foundations within the Substation. Foundations outside the Substation should include a discount depth of 1 to 2 feet.
3. USCS acronyms defined on the boring logs.
4. E_{pmt} = Modulus of deformation as would be determined from a pressuremeter test in kips per square inch.

Table 2
Recommended MFAD Design Parameters and Subsurface Characterization
Imperial Valley Substation
(Continued)

Depth Below Proposed Grade (feet)	Anticipated USCS Range	Total Unit Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)	E_{pmt} (ksi)	Shear Strength Reduction Factor, α
Zone E						
0 to 7	SM	110	33	0	1.5	1.0
7 to 10	ML	110	29	0	1.5	1.0
10 to 25	SM	115	33	0	1.5	1.0
25 to 30	SW, SM	120	35	0	2.0	1.0
Zone F						
0 to 5	SM/CL	110	30	0	1.5	1.0
5 to 15	SM	110	33	0	1.5	1.0
15 to 20	SW	110	33	0	1.5	1.0
20 to 30	SP to SM	115	35	0	2.0	1.0
Zone G						
0 to 5	SP	110	33	0	1.5	1.0
5 to 20	ML, CL, CL-ML	115	29	0	1.75	0.6
20 to 25	CH	120	27	0	2.0	0.6
25 to 30	SP to SM	125	35	0	2.0	1.0
Zone H						
0 to 15	CL-ML, CL, ML	110	29	0	1.75	0.6
15 to 30	SM	115	33	0	1.5	1.0

Notes:
1. The design groundwater level is 30 feet below existing grade.
2. No discount depth is recommended for deep foundations within the Substation. Foundations outside the Substation should include a discount depth of 1 to 2 feet.
3. USCS acronyms defined on the boring logs.
4. E_{pmt} = Modulus of deformation as would be determined from a pressuremeter test in kips per square inch.

Table 3
Group Efficiencies for Drilled Piers Founded in Granular Material
Imperial Valley Substation

Pier Spacing	Axial Group Efficiency [a, c]	Lateral Group Efficiency [b, c] (in line w/group)	Lateral Group Efficiency [b, c] (perpendicular to group)
2B	0.65	0.76	1.0
3B	0.70	0.80	1.0
4B	0.75	0.84	1.0
5B	0.85	0.88	1.0
6B	0.90	0.92	1.0
7B	0.95	0.96	1.0
8B	1.00	1.00	1.0

Notes:
1. For both downward and uplift capacities.
2. For lateral capacity.
3. Efficiency factors can be interpolated for intermediate spacings.

Table 4
Summary of Corrosivity Testing
Imperial Valley Substation

Test Location	pH	Minimum Resistivity (ohm-cm)	Water Soluble Sulfates (ppm)	Chloride (ppm)
Boring B-1 Depth of 1ft	8.9	1,750	784	285
Boring B-1 Depth of 10 ft	8.2	350	368	420
Boring B-1 Depth of 30 ft	8.1	240	544	765
Boring B-6 Depth of 10 ft	8.5	2,500	736	240
Boring B-7 Depth of 3 ft	7.0	5,000	816	195
Caltrans Guidelines Indicate Corrosive Environment if:	<5.5	<1,000	>2,000	>500

Table 5
Seismic Qualification Level Calculation
Imperial Valley Substation

Parameter	Value	Reference
Site Soil Class	D	2006 IBC Table 1615.1.1
MCE Ground Motion 0.2s Spectral Response Acceleration, S_s	1.45*g*	2006 IBC Figure 1615 (3)
Site Coefficient, F_a	1.0	2006 IBC Table 1615.1.2 (1)
Adjusted MCE Spectral Response Acceleration -short period, S_{ms} (=S_sF_a)	1.45*g*	IEEE 8.6.2.1 (d) ; IBC Equation 16-38
Peak Ground Acceleration (PGA) for seismic qualification selection (S_{ms}/2.5)	0.57*g*	IEEE 8.6.2.1 (e)
Selected Seismic Qualification Level	High	IEEE 8.6.2.1 (f)

Note:
1. g = indicates units of gravity

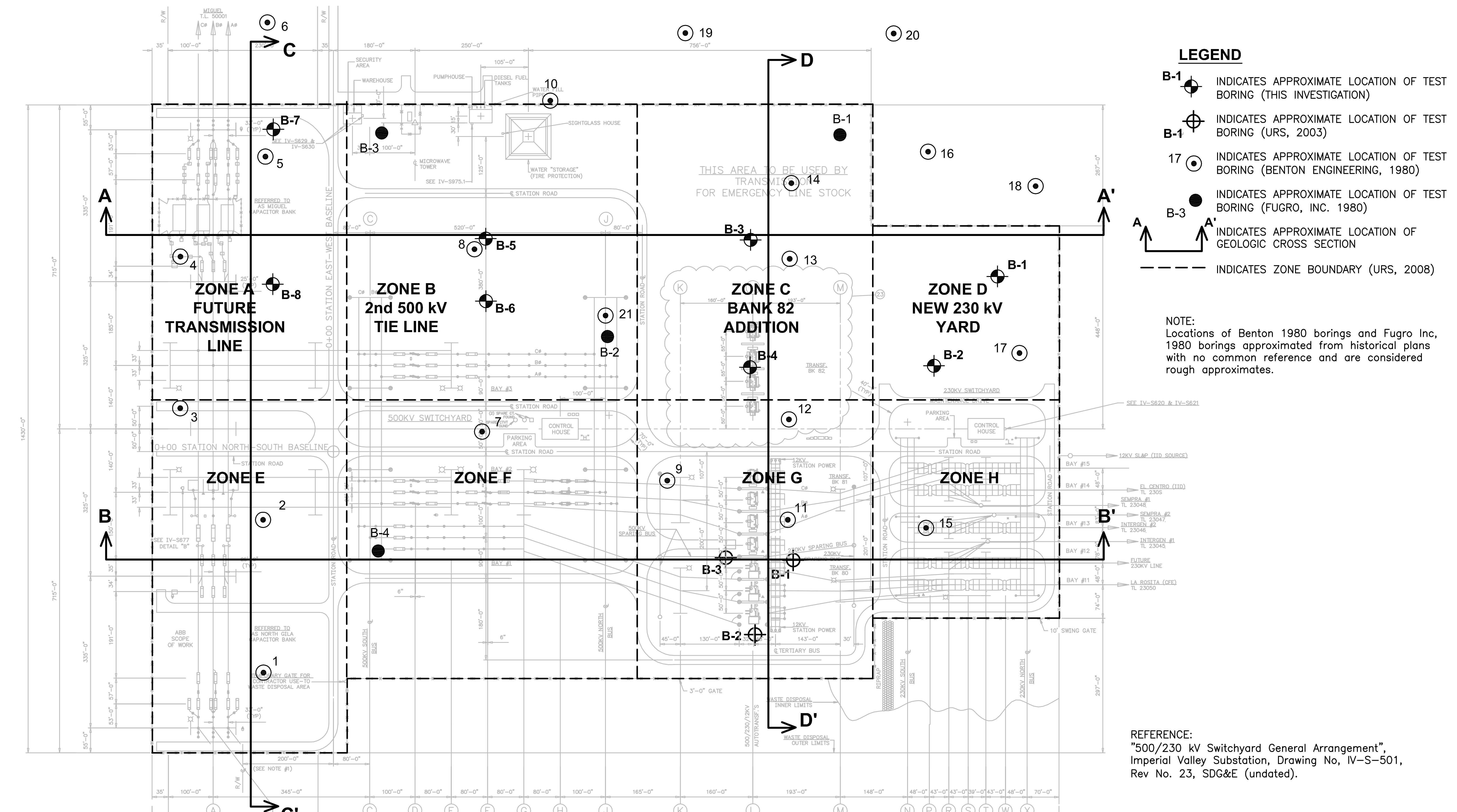
Table 6
Preliminary Cal OSHA Soil Types
Imperial Valley Substation

Geological Unit	Cal OSHA Soil Type
Fill	Type C
Fine Grained Deposits	Type B
Granular Deposits	Type C

REFERENCE: GoogleMaps

VICINITY MAP SDG&E - IMPERIAL VALLEY SUBSTATION IMPERIAL VALLEY, CALIFORNIA			
URS	NOT TO SCALE	CHECKED BY: JLN	DATE: 06-10-09	FIG. NO: 1
		PM: KCG	PROJ. NO: 27668011.00010	

X:\27668011\IV Substation Vicinity Map.dwg Jun 08, 2009 - 1:17pm



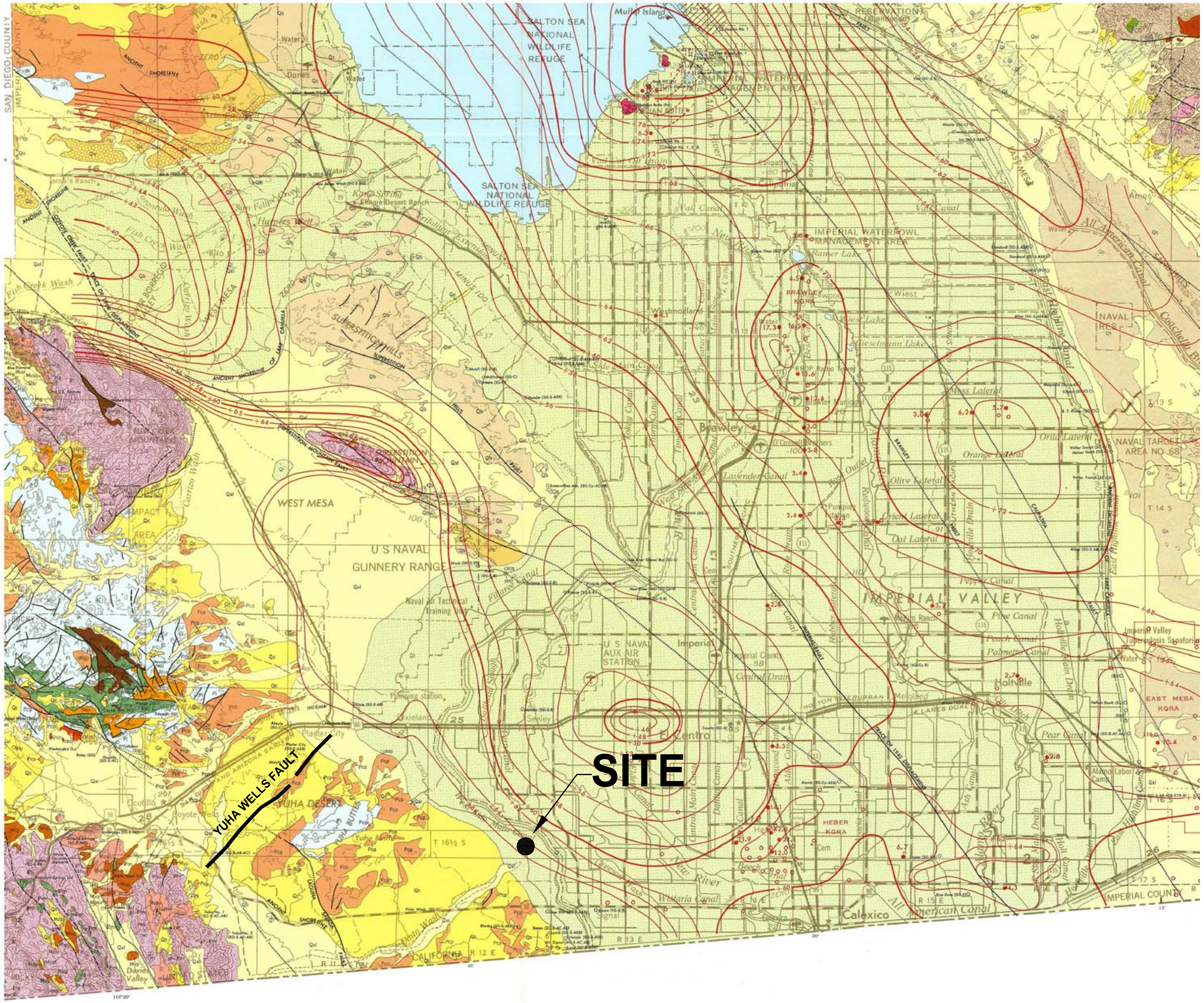
SITE PLAN
SDG&E - IMPERIAL VALLEY SUBSTATION
IMPERIAL VALLEY, CALIFORNIA

URS

SCALE: 1"= 200'

CHECKED BY: JLN	DATE: 06-11-09	FIG. NO:
PM: KCG	PROJ. NO: 27668011.00010	2

X:\27668011\IV Substation Site Plan 2.dwg Jun 09, 2009 - 9:33am



EXPLANATION

ROCKS OF COUNTY WIDE DISTRIBUTION

CENOZOIC
QUATERNARY
Holocene

Qal — Alluvium
Unconsolidated clay, silt, sand, and gravel occurring primarily as valley fill and streamwash deposits.

Qs — Dune sands
Unconsolidated sand and silty sand. Includes both Holocene and Pleistocene ages.

Qc — Older alluvium
Partly dissected largely unconsolidated, poorly sorted silt, and gravel of alluvial fans, desert pavement areas, margins of larger canyons, and terraces. Includes Chemehuevis Formation.

CENOZOIC ROCKS OF IMPERIAL VALLEY AND WESTERN IMPERIAL COUNTY

Pleistocene

Ql — Lake beds
Sediments of ancient lake Cahuilla and playa lakes. Tan and gray fossiliferous clay, silt, sand and gravel in conjunction with Qal (shown $\frac{Ql}{Qal}$).

Qv — Volcanic rocks
Rhyolite, pumice and obsidian occurring at and adjacent to volcanic domes near the southeast shore of the Salton Sea.

Qb — Brawley Formation
Light gray clays, sandstone, and pebble gravels of largely lacustrine origin; unit grades laterally into Ocotillo Conglomerate.

Qo — Ocotillo Conglomerate
Nonmarine gray granitic pebble conglomerate; grades basinward into Brawley Formation, except at Superstition Mountain where it underlies the Brawley Formation.

TERTIARY
Pliocene

Pb — Borrego Formation
Nonmarine gray clay and interbedded sandstone of lacustrine origin; contains lenses of sodium sulfate near Bertram.

Pcc — Canebrake Conglomerate
Composed largely of granitic debris. Represents marginal facies of Palm Spring and Imperial Formations.
Pcct = Truckhaven Rhyolite Member, varicolored rhyolite flow.

Pcp — Palm Spring Formation
Interbedded nonmarine, light gray, arkosic sandstone and reddish clay; grades into Canebrake Conglomerate towards margins of Salton basin.

Pi — Imperial Formation
Marine sequence of light yellow-gray clay, interbedded arkosic sandstone with oyster-shell reefs, and fossiliferous calcareous sandstone.

Miocene

Mg — Fish Creek Gypsum
Thick massive beds of pure gypsum, minor anhydrite and celestite.

Mva / Mvp — Alverson Andesite
Varicolored andesite flows and interbedded tuff, breccia, and nonmarine sediments.
Mvp = Jacumba pyroclastic rocks

Mcs (Mcsl, Mcsu) — Split Mountain Formation
Mcsu = Upper member; gray conglomerate and brown arkosic sandstone
Mcsl = Lower member; reddish-brown arkosic sandstone, conglomerate, and sedimentary breccia.

CENOZOIC ROCKS OF THE CHOCOLATE MOUNTAINS AND EASTERN IMPERIAL COUNTY

TERTIARY
Pliocene

Tbs — Bouse Formation
Interbedded marine to brackish water limestone, siltstone, sandstone and tufa.

Tc / Tcv — Clastic rocks
Tc = non-marine clastic rocks and volcanic conglomerate.
Tcv = yellow-gray, moderately to poorly consolidated, poorly sorted pebbly siltstone, sandstone and conglomerate. Includes both pre- and post-basalt units of widely variant composition.

Tvb — Basalt flows
Fine-grained vesicular basalt and minor interbedded conglomerate overlie and underlie non-marine clastic rocks.

Tl — Inter-volcanic lakebeds
Interbedded white, flaggy tuffs, and gray thinly bedded limestone.

Tcr — Red sedimentary beds
Well-bedded reddish conglomerate and sandstone, largely devoid of volcanic debris except minor andesite.

Tv — Volcanic rocks
Tvi = intrusive
Tvp = pyroclastic
Tvr = rhyolitic
Tva = andesitic
Tvia = intrusive andesite
Tv = undifferentiated

Tbr — Sedimentary breccia
Pale grayish-yellow, poorly sorted breccia composed largely of metavolcanic and metasedimentary rocks in a poorly to moderately well cemented matrix of silt to sand.

SYMBOLS

Contact
(*dashed where approximately located; dotted where concealed; queried where inferred*)

Fault
(*dashed where approximately located; dotted where concealed; queried where inferred*)

Thrust fault
(*barb on upper plate*)

CO_2 Field

Mill or abandoned mill

Steamwell

Mine or prospect

(AB) —Aggregate base (sand and gravel)
(AC) —Asphalt concrete (sand and gravel)
(Ag) —Silver
(ASB) —Aggregate sub-base (sand and gravel)
(Au) —Gold
(B) —Borrow (sand and gravel)
(Ba) —Barite
(C) —Commercial pit (sand and gravel)
(Cl) —Clay
(CTB) —Cement treated base (sand and gravel)
(Cu) —Copper
(Cy) —County source (sand and gravel)
(Fe) —Iron
(G) —Gemstone locality
(Gyp) —Gypsum
(Ky) —Kyanite
(Ls) —Limestone
(M) —Mica (sericite)
(Mn) —Manganese
(Ni) —Nickel
(Pb) —Lead
(Pc) —Pumice
(Py) —Pyrophyllite
(SiO_2) —Silica
(SG) —Sand and gravel
(RG) —Roof granules
(RQ) —Rock quarry
(S) —State source (sand and gravel)
(Sl) —Salines
(Sr) —Strontium
(St) —Stone
(W) —Tungsten
(U) —Uranium

O118
Temperature wells by U.S.B.R. and others Numbers (115) are U.S.B.R. designation.

+90
+88
Bouguer gravity contours*
(*Contour interval 2 milligals*)
Note: 1000 milligals have been added to all readings and the first digit is omitted; thus 84 is actually 984 - 1000 or -16 milligals (Gravity by Shawn Biehler in Meidav and Rex, 1970)

● 11.9
Geothermal gradient in degrees Fahrenheit per 100 feet depth.*

3
Isothermal depth contours for a 300° C surface. (After Helgeson, 1968)

KGRA
KGRA = Known Geothermal Resources Area Designated by U.S.B.R.

SOURCE: "Geologic Map of Imperial County, California, Showing Mines and Minerals Deposits", complied by Paul K. Morten, 1966

LEGEND

Faults modified by "Fault Activity Map of California and Adjacent Areas", Division of Mines and Geology, Geologic Data Map No. 6, complied by Charles W. Jennings (1994)

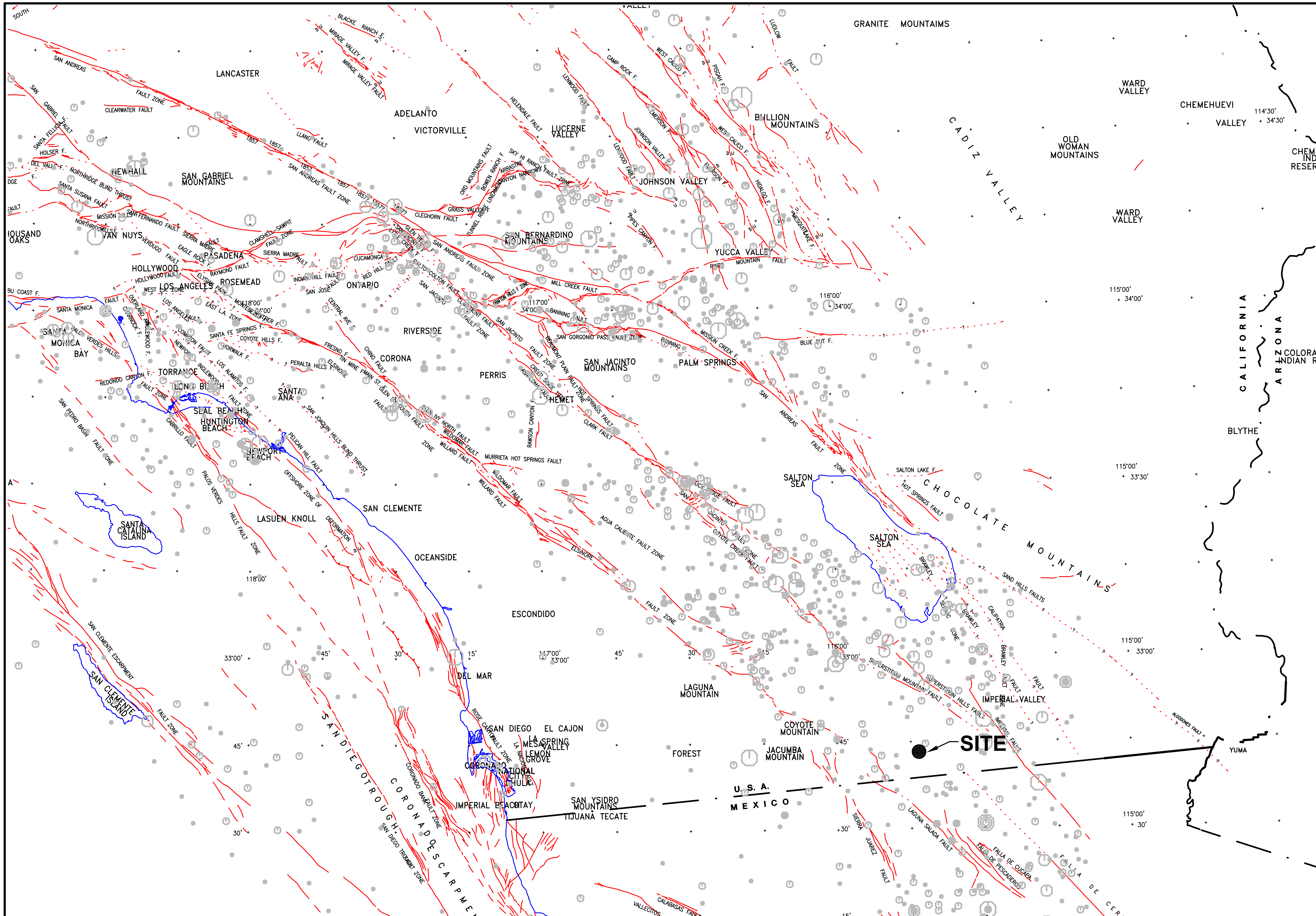
N

URS

REGIONAL GEOLOGIC MAP
SDG&E - IMPERIAL VALLEY SUBSTATION
IMPERIAL VALLEY, CALIFORNIA

2.5 0 2.5 5 miles SCALE: 1"= 5 miles	CHECKED BY: JLN	DATE: 06-11-09	FIG. NO.
	PM: KCG	PROJ. NO: 27668011.00010	3

X:\27668011\IV Substation Geology Map 6-9-09.dwg Jun 16, 2009 - 8:27am



LEGEND:

REPORTED EARTHQUAKE MAGNITUDES.

- 4.0 TO 4.9
- 5.0 TO 5.9
- 6.0 TO 6.9
- 7.0 AND GREATER

SOUTH OF LATITUDE 35°N, EPICENTER AND MAGNITUDE DATA ARE FROM THE CALIFORNIA GEOLOGICAL SURVEY (2000) EARTHQUAKE CATALOG FOR THE PERIOD FROM 1769 TO 2000. ONLY EARTHQUAKES OF MAGNITUDE 4.0 AND LARGER ARE SHOWN. AFTERSHOCKS ARE NOT INCLUDED.

? ? ?

APPROXIMATE LOCATION OF HOLOCENE AND PLEISTOCENE FAULTS, DOTTED WHERE CONCEALED, QUERIED WHERE CONJECTURAL. FAULT LOCATIONS BASED ON: ZIONY AND JONES, 1989; CDMG GEOLOGIC MAP SERIES OF CALIFORNIA, 1977–1986 (1:250,000 SCALE); CDMG GEOLOGIC MAP SERIES, CALIFORNIA CONTINENTAL MARGIN, 1987 (1:250,000 SCALE); HAUKSSON, 1990; SHAW AND SHEARER, 1999; WRIGHT, 1991; GRANT ET AL. 1999.

N

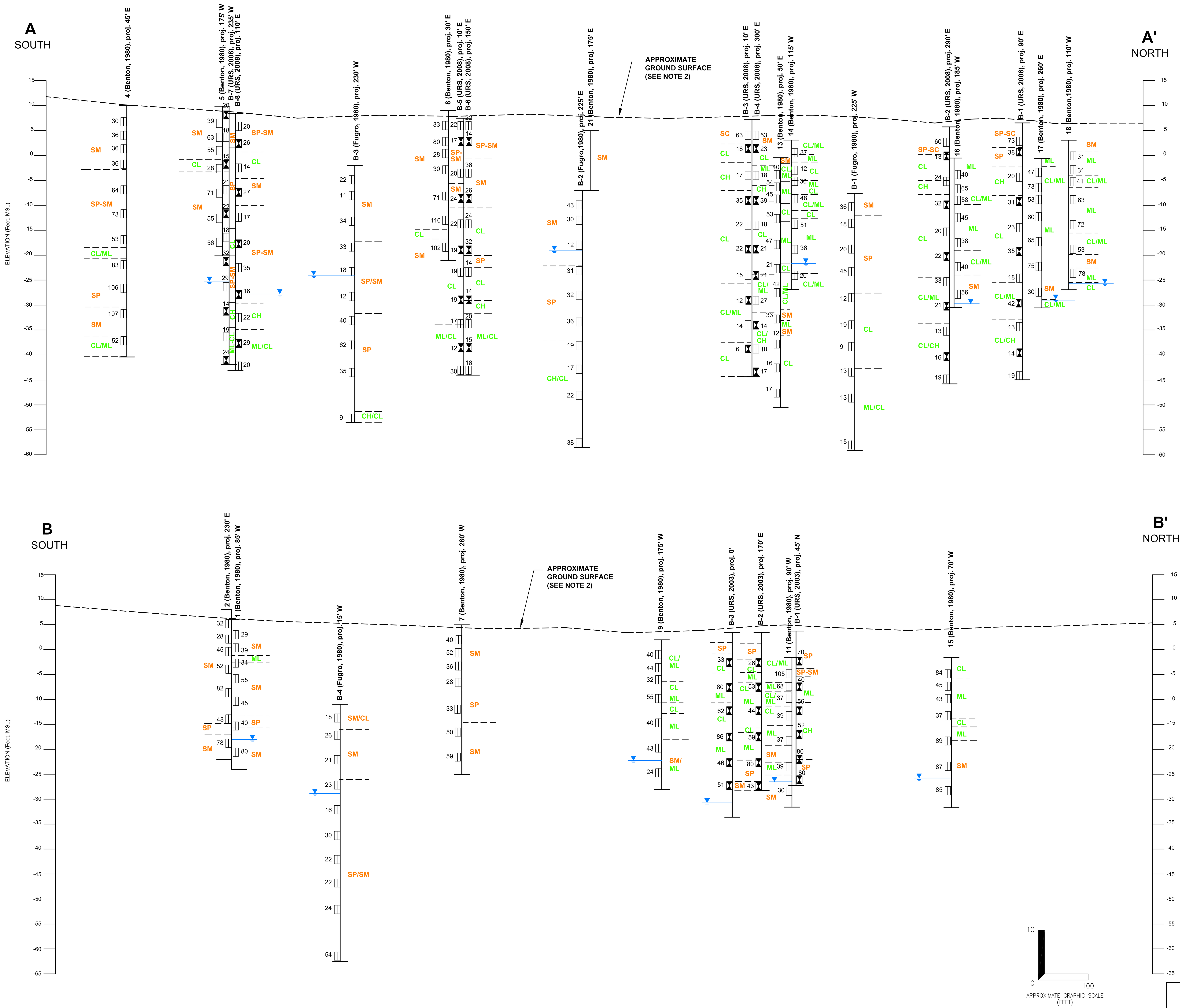
REGIONAL FAULT AND EPICENTER MAP
SDG&E - IMPERIAL VALLEY SUBSTATION
IMPERIAL VALLEY, CALIFORNIA

URS

10 0 10 20 Miles

SCALE: 1"= 20 miles

CHECKED BY: JLN	DATE: 06–10–09	FIG. NO:
PM: KCG	PROJ. NO: 27668011.00010	4



LEGEND

B-1	BORING NUMBER, (REFERENCE), PROJECTD DISTANCE AND DIRECTION
	STANDARD PENETRATION TEST (SPT) SAMPLE LOCATION
	MODIFIED CALIFORNIA (MODCAL) SAMPLE LOCATION
36	SPT N-VALUE BLOWCOUNT (REDUCED BY 0.8 FOR URS MODCAL SAMPLES)
	APPROXIMATE LITHOLOGIC CONTACT
	REPORTED GROUNDWATER AT TIME OF DRILLING
SP, SM	USCS SYMBOL – GRANULAR ALLUVIAL DEPOSITS
ML, CL	USCS SYMBOL – FINE-GRAINED LACUSTRINE DEPOSITS

NOTES:

1. Locations of Benton 1980 borings and Fugro Inc, 1980 borings approximated from historical plans with no common reference and are considered rough approximates.
2. Ground surface approximated from as-built plans for substation construction.

10
0
100
APPROXIMATE GRAPHIC SCALE (FEET)
VERTICAL EXAGGERATION 10X

GENERALIZED GEOLOGIC CROSS SECTIONS A-A' AND B-B'
SDG&E - IMPERIAL VALLEY SUBSTATION
IMPERIAL VALLEY, CALIFORNIA

URS

CHECKED BY: JLN	DATE: 06-10-09	FIG. NO:
PM: KCG	PROJ. NO: 27668011.00010	5

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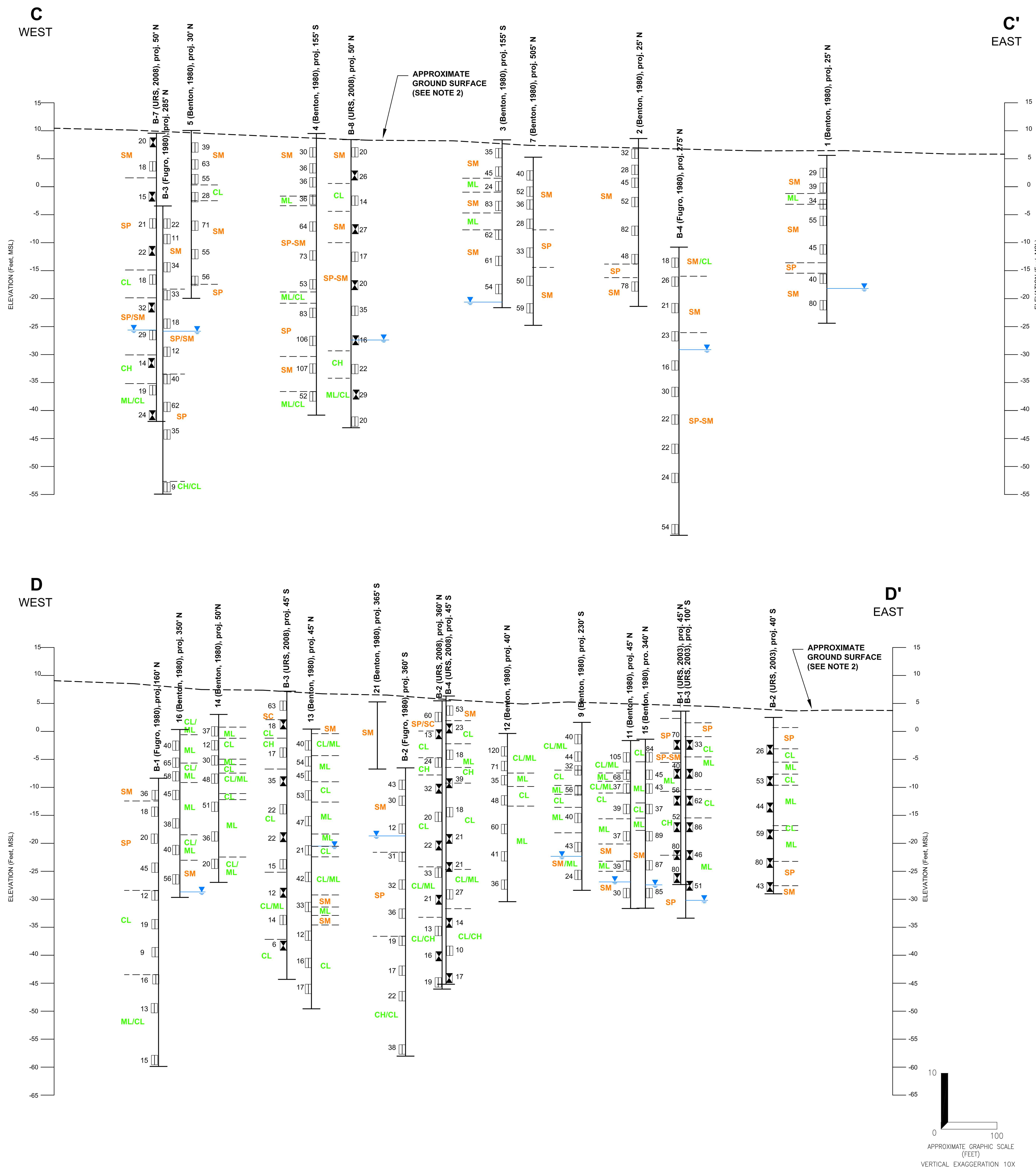

LEGEND

B-1 BORING NUMBER, (REFERENCE), PROJECTD DISTANCE AND DIRECTION

STANDARD PENETRATION TEST (SPT) SAMPLE LOCATION

MODIFIED (MODCAL) CALIFORNIA SAMPLE LOCATION

36 SPT N-VALUE BLOWCOUNT (REDUCED BY 0.8 FOR URS MODCAL SAMPLES)

APPROXIMATE LITHOLOGIC CONTACT

REPORTED GROUNDWATER AT TIME OF DRILLING

SP, SM USCS SYMBOL – GRANULAR ALLUVIAL DEPOSITS

ML, CL USCS SYMBOL – FINE-GRAINED LACUSTRINE DEPOSITS

NOTES:

1. Locations of Benton 1980 borings and Fugro Inc, 1980 borings approximated from historical plans with no common reference and are considered rough approximates.

2. Ground surface approximated from as-built plans for substation construction.

GENERALIZED GEOLOGIC CROSS SECTIONS C-C' AND D-D'
SDG&E - IMPERIAL VALLEY SUBSTATION
IMPERIAL VALLEY, CALIFORNIA

URS

CHECKED BY: JLN	DATE: 06-10-09	FIG. NO:
PM: KCG	PROJ. NO: 27668011.00010	6

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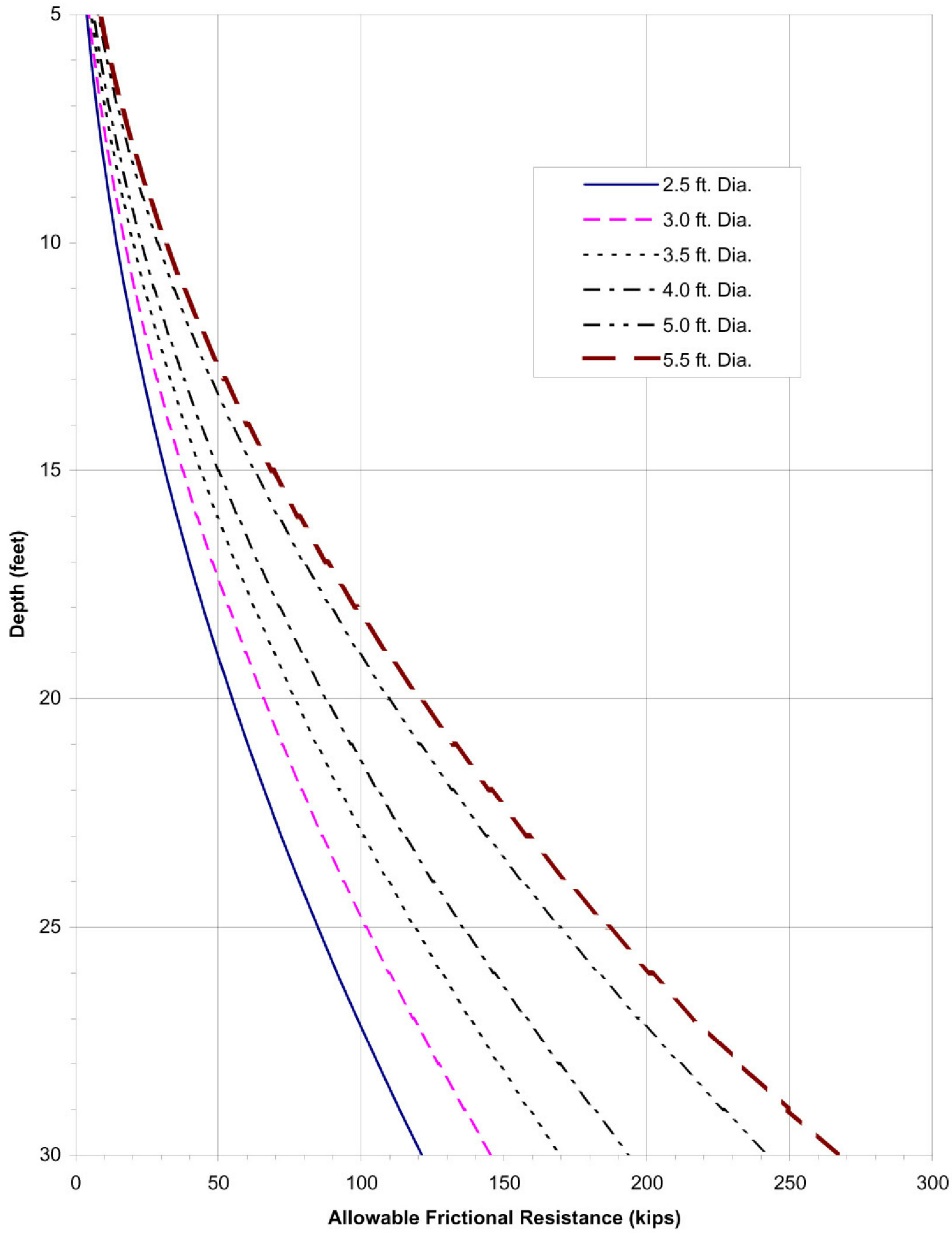
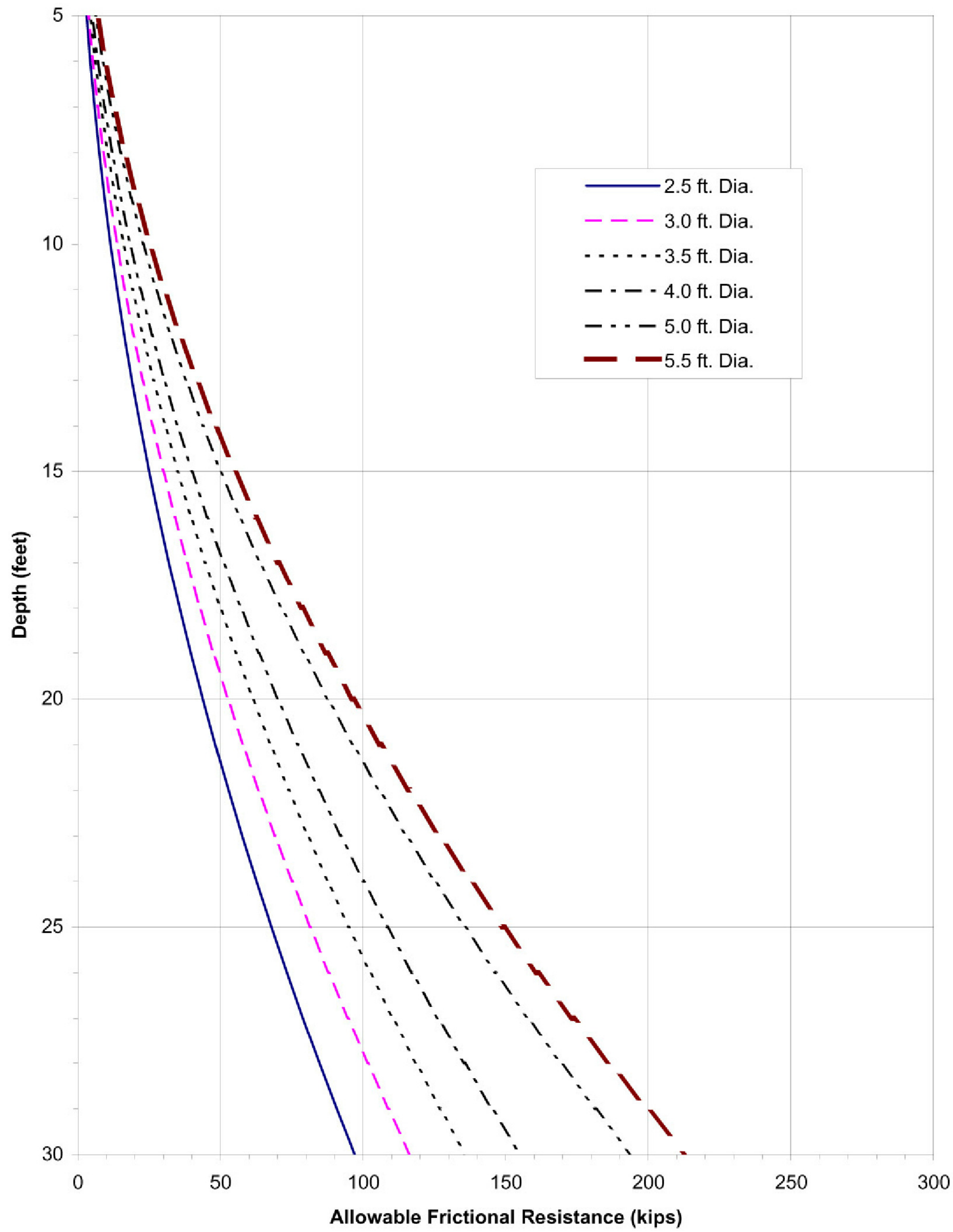


ALLOWABLE DOWNWARD FRICTIONAL REISISTANCE
DRILLED PIER FOUNDATIONS
SDG&E - IMPERIAL VALLEY SUBSTATION
IMPERIAL VALLEY, CALIFORNIA

URS	CHECKED BY: JLN	DATE: 06-10-09	FIG. NO:
	PM: KCG	PROJ. NO: 27668011.00010	7



ALLOWABLE UPWARD FRICTIONAL REISISTANCE
DRILLED PIER FOUNDATIONS
SDG&E - IMPERIAL VALLEY SUBSTATION
IMPERIAL VALLEY, CALIFORNIA

URS	CHECKED BY: JLN	DATE: 06-10-09	FIG. NO:
	PM: KCG	PROJ. NO: 27668011.00010	**8**

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Copies of boring logs and laboratory test data from previous investigations by URS and others are provided in this appendix.

BENTON, 1980

SOILS INVESTIGATION

PROPOSED IMPERIAL VALLEY SUBSTATION
PHASE III, SITE 7A
IMPERIAL COUNTY, CALIFORNIA

Prepared for the

SAN DIEGO GAS & ELECTRIC COMPANY

by

BENTON ENGINEERING, INC.

PROJECT NO. 80-9-10A

NOVEMBER 14, 1980

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT.)

Project No. [illegible]0-9-10A

BENTON ENGINEERING, INC.
APPLIED SOIL MECHANICS — FOUNDATIONS
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SOILS INVESTIGATION

Introduction

This is to present the results of a soils investigation conducted at Site 7A of the proposed Imperial Valley Substation of San Diego Gas & Electric Company in Imperial Valley, San Diego County, California.

The site was previously investigated by FUGRO, INCORPORATED of Long Beach, California in order to study its feasibility for meeting construction permit requirements. In their study, five borings were drilled at the site, and the findings from the borings were used as reference for this investigation.

It is understood that the objectives of this investigation were to develop certain soil parameters, commensurate with the tested soil properties, for the foundation design of the proposed substation.

In order to accomplish these objectives, twenty-one borings were drilled by our firm, and both loose and undisturbed soil samples were obtained for laboratory testing.

This investigation was based on our proposal to San Diego Gas & Electric Company dated August 15, 1980.

Field Investigation

Borings 1 to 20 inclusive were drilled 4.5 inches in diameter with a rotary wash rig and Boring 21 was drilled 30 inches in diameter with a rotary bucket-type drill rig at the approximate locations shown on the attached Drawing No. 1, entitled "Location of Test Borings." The borings were drilled to depths of 12 to 50 feet below the existing ground surface. A continuous log of the soils encountered in the borings was recorded at the time of drilling and is shown in detail on Drawing Nos. 2 to 44, inclusive, each entitled "Summary Sheet."

Project No. 80-9-10A

The soils were visually classified by field identification procedures in accordance with the Unified Soil Classification Chart. A simplified description of this classification system is presented in the attached Appendix A at the end of this report.

Undisturbed samples were obtained at frequent intervals, where possible, in the soils ahead of the drilling. The drop weight used for driving the sampling tube into the soils was either 300 pounds for the rotary wash drill rig or 3,770 pounds for the rotary bucket-type drill rig. The average drop was 12 inches for the rotary bucket-type drill rig and 30 inches for the rotary wash drill rig. The general procedures used in field sampling are described under "Sampling" in Appendix B. During the course of drilling, the blow counts required to drive a standard splitspoon sampler for a distance of 6 inches were recorded. The recorded blow counts are shown on the attached Drawing Nos. 2 to 44, inclusive. To obtain the required blow counts for driving the sampler for a distance of 12 inches, the last two recorded blow counts should be combined.

Laboratory Tests

Laboratory tests were performed on all undisturbed samples of the soils in order to determine the dry density, moisture content and shearing strength. To test the shearing strength of the soils, the soil samples were sheared under a normal pressure equal to their effective overburden pressures. For those recovered above ground water table, the soil samples were sheared under field moisture condition. For those recovered below water table, they were sheared in a saturated undrained condition. The results of these tests are presented on Drawing Nos. 2 to 44, inclusive. Consolidation tests were performed on representative samples in order to determine the load-settlement characteristics of the soils and the results of these tests are presented graphically on Drawing Nos. 45 to 52, inclusive each entitled "Consolidation Curves." The general procedures used for the laboratory tests are described briefly in Appendix B.

In addition to the above laboratory tests, expansion tests were performed on some of the clayey soils encountered to determine their volumetric change characteristics with change in moisture content. The recorded expansions of the samples are presented as follows:

Boring No.	Sample No.	Depth of Sample, in Feet	Soil Description	Percent Expansion Under Unit Load of 500 Pounds per Square Foot from Air Dry to Saturation
9	1	2.5	Clayey Silt	0.27
14	1	2.5	Silty Clay	3.11
20	1	2.5	Clayey Silt	6.71

California Bearing Ratio tests were performed on representative samples of the subgrade soils at the site. The tests were performed in accordance with A.S.T.M. D1883 and D1557 Method D modified per City of San Diego standards. The test results are presented below:

CBR Sample No.	Depth in Feet	Molded Dry Density lb/cu ft	Initial Moisture Content % dry wt	Pene-tration Inch	Load in Pounds on 3 Sq. In. Plunger	CBR % of Std.	Percent Expansion During Soaking	Percent Moisture After Penetration
2	0 to 1.0	110.7	7.0	0.1	316.0	10.5	0.06	17.0
				0.2	527.8	11.7		
				0.3	558.5	9.8		
				0.4	589.1	8.5		
				0.5	650.3	8.3		
4	0 to 1.0	114.8	17.3	0.1	110.6	3.69	3.46	25.6
				0.2	229.1	5.09		
				0.3	323.9	5.68		
				0.4	402.9	5.84		
				0.5	466.9	5.98		
5	0 to 1.0	121.8	15.4	0.1	102.7	3.42	5.04	25.6
				0.2	165.9	3.69		
				0.3	229.1	4.02		
				0.4	284.4	4.12		
				0.5	331.8	4.25		

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Unconfined compression tests were conducted on certain clayey soil samples in order to determine their strength characteristics. The results of the tests are presented below:

Boring Nos.	Sample Nos.	Depth Below Existing Ground Surface In Feet	Soil Description	Compressive Strength (KSF)	Shearing Strength (KSF)
9	3	10.0	Clay	13.02	6.51
	4	15.0	Clay	5.48	2.74
	5	20.0	Silt with lenses of silty clay	3.36	1.68
11	1	2.5	Silty clay	14.57	7.28
	2	5.0	Silty clay with silt lenses	4.71	2.35
	3	10.0	Clay	11.99	6.00
	4	15.0	Silt, thinly bedded	3.00	1.50
12	1	2.5	Silty clay with silt lenses	8.52	4.26
	2	5.0	Silty clay with silt lenses	20.74	10.37
	3	10.0	Clay	9.72	4.86
	4	15.0	Silt interbedded with sandy silt	2.68	1.34
	5	20.0	Silt with lenses of silty clay	4.16	2.08
13	3	10.0	Clay	5.34	2.67
14	4	15.0	Clay	6.22	3.11
15	1	2.5	Clay	12.33	6.17
	2	5.0	Silt with lenses of silty clay	0.77	0.39
	3	10.0	Silt with lenses of silty clay	4.81	2.41
16	1	2.5	Silt interbedded with silty clay	15.05	7.53
	2	5.0	Silt interbedded with silty clay	14.83	7.42
	3	10.0	Fine sandy silt	3.42	1.71
17	1	2.5	Silty clay with thin layers of silt	8.68	4.34
20	3	10.0	Silt with lens of fine sandy silt and silty clay	1.40	0.70

Chemical analysis was conducted on selected loose soil samples in order to determine their corrosive characteristics. The tests were conducted by the Environmental Engineering Laboratory of San Diego, California. Their test results are attached at the end of this report as Appendix C.

In order to differentiate the strength characteristics of soils between field moisture and saturated conditions, certain selected soil samples were also tested under both field moisture and saturated conditions. The results of the tests are presented below:

Boring Nos.	Sample Nos.	Sample Depth Feet	Normal Load Kips/Sq.Ft.	Maximum Shear Load Tested Under Field Moisture Condition Kips/Sq.Ft.	Maximum Shear Load Tested Under Saturated, Undrained Condition Kips/Sq.Ft.
1	3	10.0	1.147	1.38	1.23
1	4	15.0	1.696	1.87	1.78
2	1	2.5	0.245	0.32	0.28
2	3	10.0	1.126	1.41	1.22
2	5	20.0	2.220	2.51	2.16
3	6	25.0	2.690	2.70	2.42
4	3	10.0	1.120	1.49	1.22
4	5	20.0	2.260	2.70	2.40
5	4	15.0	1.665	1.94	1.53
5	5	20.0	2.195	2.65	2.17
7	1	2.5	0.245	0.36	0.36
7	3	10.0	1.068	1.50	1.04
7	5	20.0	2.220	2.40	1.96
8	1	2.5	0.245	0.26	0.12
8	5	20.0	2.130	1.99	1.74
10	4	15.0	1.572	1.27	1.06
13	2	5.0	0.550	3.23	0.47
13	4	15.0	1.525	1.51	1.14
13	5	20.0	2.090	2.25	1.58
14	3	10.0	1.100	3.09	0.74
14	5	20.0	2.130	2.56	1.66
14	6	25.0	2.700	3.81	2.13
17	3	10.0	1.210	1.88	1.56
17	4	15.0	1.760	2.31	1.37
17	5	20.0	2.250	2.44	1.21
18	2	5.0	0.527	1.58	0.67
18	3	10.0	1.017	1.11	0.67
18	4	15.0	1.572	2.88	2.01
18	5	20.0	2.185	3.04	1.94
19	4	15.0	1.810	3.86	1.50
20	2	5.0	0.550	1.80	1.14
21	1	4.0	0.493	0.55	0.50
21	2	6.0	0.693	0.65	0.52
21	3	8.0	0.975	1.17	0.91

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

Subsurface Conditions

At the site, two distinctive soil deposits, described as alluvial fan deposit and lacustrine deposits of ancient Lake Cahuilla by Fugro Incorporated of Long Beach, California, were also encountered in our twenty-one borings drilled.

The alluvial fan deposit consists mainly of more granular and permeable soils, such as silty sand, slightly silty sand and sandy soils of various grain sizes with occasional inclusion of thin layers of fine sandy silt, fine sandy clay and clay and silty clay soils. The lacustrine deposit of ancient Lake Cahuilla consists mainly of interbedded clay, silty clay, silt and clayey silt which were fine-grained and less permeable.

Based on the results of field exploration, the alluvial fan deposit covers the southern portion of the site where Borings 1 to 8 inclusive, Borings 10 and 21 were drilled. Borings 2 and 4 by Fugro Incorporated were also located in the alluvial deposit area. On the northerly portion of the site, Boring 9 and Borings 11 to 20 inclusive, were drilled in the lacustrine deposit. The two deposits seem to overlap in the vicinity of Borings 4 and 5 drilled by Fugro Incorporated. Along the south boundary of the site, the alluvial fan deposit extended to Elevation -37.19 feet or to a depth of 46.7 feet below the existing ground surface at Boring 4 location. Below 46.7 feet at Boring 4 location, silty clay of lacustrine deposit was encountered. The soils of both deposits were found to be mostly medium firm to very firm or dense to very dense except the upper portion of the site where thin layers of loose to very loose soil mantle were encountered in most of the twenty-one borings drilled. The loose to very loose soil mantle consists mainly of silty sand and slightly silty sand of various grain sizes.

The depths where the loose to very loose soil mantle exists are summarized and presented on the following page.

Boring Nos.	Elevation of Existing Ground Surface in Feet*	Depth Below Existing Ground Surface Where Loose to Very Loose Soil Mantle Was Encountered, in Feet
1	5.56	0 to 5.0
2	7.68	0 to 1.5
3	8.21	0 to 1.5
4	9.51	0 to 1.0
5	9.99	0 to 1.0
6	10.60	0 to 1.5
7	5.18	0 to 1.0
8	8.91	0 to 1.0
9	1.64	Not Encountered
10	8.95	0 to 1.5
11	-1.44	Not Encountered
12	-0.36	0 to 0.8
13	0.32	0 to 0.8
14	3.04	0 to 0.4
15	-1.62	Not Encountered
16	0.42	0 to 1.0
17	-0.48	0 to 0.5
18	3.22	0 to 2.4
19	5.89	0 to 1.5
20	3.06	0 to 0.7
21	5.06	0 to 1.0

* MSL datum

Due to rotary wash type of drilling, no clear ground water level was observed during our field exploration; however, very moist or saturated soil zones were established after soil sampling and laboratory moisture test. The total depth of exploration, the depth to the surface of very moist or saturated soil zone and the existing ground surface elevation at each boring location are presented below:

Boring Nos.	Existing Ground Surface Elevation in Feet	Total Depth of Boring in Feet	Depth To The Surface of Saturated Soil Zone in Feet (**)
1	5.56	30.0	Below 24.0
2	7.68	30.0	Very moist below 23.0
3	8.21	30.0	Below 29.0
4	9.51	50.0	Below 28.5
5	9.99	30.0	*
6	10.60	30.0	*
7	5.18	30.0	Very moist below 26.0
8	8.91	30.0	Very moist below 29.0
9	1.64	30.0	Below 24.0

Boring Nos.	Existing Ground Surface Elevation in Feet	Total Depth of Boring in Feet	Depth To The Surface of Saturated Soil Zone in Feet (**)
10	8.95	30.0	Very moist below 28.0
11	-1.44	30.0	Below 25.0
12	-0.36	30.0	Very moist to saturated below 24.0 feet
13	0.32	50.0	Below 21.0
14	3.04	30.0	Very moist to saturated below 25.5 feet
15	-1.62	30.0	Below 26.0
16	0.42	30.0	Below 29.0
17	-0.48	30.0	Below 28.0
18	3.22	30.0	Below 28.5
19	5.89	30.0	Below 28.0
20	3.06	30.0	Below 29.8
21	5.06	12.0	*

* No saturated soil zone was encountered within the limit of exploration. Boring 21 could not be drilled below 12.0 feet because of the use of the bucket rig in drilling this boring.
** Surface of saturated soil zone may indicate ground water table.

Conclusions

It is concluded from the results of field exploration, laboratory tests and office analysis of both field and laboratory data that:

1. During earthquake, soil liquefaction at the site is considered unlikely because of favorable subsurface conditions. The high blow count of a standard sampler, the deep ground water table, the high clay content of the subsoils and the favorable consistency of the soils all tend to negate the possibility of soil liquefaction.

2. On the northerly half of the site where Boring 9 and Borings 11 to 20 inclusive were drilled, expansive, fine-grained soils of lacustrine deposit were encountered in the upper portion of these borings. Based on the results of laboratory tests and the visual identification of the soils, the soils with high expansive potential are clay, sandy clay and silty clay soils. The clayey silt soils are marginally expansive depending upon the amount of silty clay or clay in the clayey silt soils. The silt and fine sandy silt soils were found to be non-expansive to slightly expansive.

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3. On the southerly half of the site where Borings 1 to 8 inclusive, Borings 10 and 21 were drilled, the upper soils were found to be non-expansive. The non-expansive soils consist of silty sand, slightly silty sand and sandy soils of various grain size, silt and fine sandy silt soils. These soils are suitable for use as compacted fill materials.

4. Due to the presence of expansive soils in the upper portion of the northerly half of the site, it is desirable to cap the northerly half of the site with at least 3.0 feet of compacted fill ground that consists of the non-expansive soils obtained from the southerly half of the site.

5. During field exploration, loss of water circulation in drilling through cracked clay layers was observed in some of the borings drilled. The cracks and loss of water circulation may require special attention during construction. The depths where the cracks and the loss of water circulation in the clay layers are summarized and presented below:

Boring Nos.	Depth in Feet	Soil Description
9	13.0 to 15.5	Clay with cracks, thin lenses of silt, loss of water circulation during drilling
14	9.5 to 11.0	Clay with shrinkage cracks
14	14.5 to 15.5	Clay with shrinkage cracks
19	19.0 to 20.0	Clay with cracks and fissures, blocky structure, loss of water circulation during drilling
20	4.8 to 7.0	Clay with shrinkage cracks, loss of water circulation during drilling

6. The soils and the ground water at the site were found to be severely corrosive. Any underground structures made of steel and concrete require special preventive measures for the adverse corrosion environment.

Recommendations

1. Soil Density

The tested dry densities of the on-site soils are shown in the eighth column of the attached Drawing Nos. 2 to 44, inclusive of this report. The dry density and the tested field moisture content of the soils, shown in the seventh column of these drawings, can be used as the basis for determining moist, saturated and submerged unit weights of the soils by assuming 2.65

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for the specific gravity of the soils.

2. Ultimate Vertical Bearing Capacity

The recommended bearing capacities of soils for the design of conventional square and continuous footings at the site are presented below:

	Footings On Medium Firm To Very Firm, Undisturbed Natural Soils Of Alluvial Fan Deposit (*)		Footings On Medium Firm To Very Firm, Undisturbed Natural Soils Of Lacustrine Deposit (*)		Footings On Compacted Filled Ground Consisting of Non-Expansive On-Site Soils
	Square Footing	Continuous Footing	Square Footing	Continuous Footing	For Both Square and Continuous Footing
a) Bearing value of two-foot wide square footing and one-foot wide continuous footing at 1.0 foot below final ground surface under field moisture condition. (psf)	4,000	3,200	3,500	3,000	3,000 under field moisture condition
b) Rate of allowable increase in bearing value for each additional foot of depth below 1.0 foot (psf/ft)					
Field Moisture Condition	1,100	1,100	210	210	
Submerged Condition	350	350	90	90	
c) Rate of allowable increase in bearing value for each additional foot of width increase (psf/ft)					
Field Moisture Condition	480	600	25	35	
Submerged Condition	140	180	20	25	
d) Recommended maximum bearing value (psf)	6,000	6,000	4,200	4,200	3,000 under field moisture condition

* See "Subsurface Conditions" section and Conclusions 2 and 3

3. Ultimate Moist Skin Friction and the Ratio of Skin Friction under Moist and Submerged Condition.

For the design of deep foundations which obtain their supporting capacity mainly from skin friction, the unit skin friction and the corresponding depth may be estimated from the shearing

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resistances of soils presented in the last two columns (columns 9 and 10) of Drawing Nos. 2 to 44, inclusive. The shearing resistances presented in column 9 were obtained by shearing the soil samples at their existing overburden pressures under field moisture condition for those obtained above water table. For those obtained below water table or below saturated soil zones, the soil samples were sheared at their existing effective overburden pressure under saturated-undrained condition. The shearing resistances presented in the last column (column 10) were obtained by saturating selected soil samples above ground water table before test and then shearing the soil samples under a saturated-undrained condition.

The skin friction under field moisture condition may be obtained from the shearing strengths of the soils shown on column 9 of Drawing Nos. 2 to 44 inclusive, divided by 3 for those above ground water table. For example, the shearing resistance of the fine to coarse sand encountered between 19.0 feet and 21.0 feet at Boring 1 was tested to be 3.27 kips per square foot under field moisture condition as shown on Drawing No. 3. Therefore, the estimated skin friction of this zone will be $3.27 \div 3 = 1.09$ kips per square foot. The skin friction under submerged condition may be derived by the shearing strengths of the soils shown on column 10 of Drawing Nos. 2 to 44 inclusive, divided by 2. Where no saturated shearing strengths are shown on column 10, the saturated shearing strengths above ground water table may be derived by the following procedures which were developed on the basis of the average reduction in shearing resistances tested under both field moisture and saturated-undrained condition:

$$S9 \times R = S10$$

where

S9: the shearing resistance of soils above ground water table shown in column 9 of Drawing Nos. 2 to 44 inclusive.

R: Average reduction factor for shearing resistance tested under saturated-undrained condition.

S10: The desired saturated-undrained shearing resistance of soils in column 10 for determining submerged skin friction of the soils above ground water table. If saturated shearing resistance of the soils was tested, the tested value shown on column 10 should be used in lieu of S10.

The average reduction factors developed on the results of the laboratory tests are presented below:

	Recommended Average Reduction Factor, R.
The soils of alluvial fan deposit such as silty sand, slightly silty sand, fine to coarse sand and fine sandy silt	0.82
The clay, silt clay, sandy clay and clayey silt soils of lacustrine deposit	0.38
The silt and silty sand of lacustrine deposit	0.67

To obtain the submerged skin friction values of the soils above ground water table, divide the derived S10 values by 2.

4. Apparent Cohesion and Angle of Internal Friction

The recommended apparent cohesion and the angle of internal friction values per laboratory soil tests are presented below:

	Field Moisture Condition		Saturated Condition	
	Apparent Cohesion in psf	Angle of Internal Friction in Degrees	Apparent Cohesion in psf	Angle of Internal Friction in Degrees
Alluvial fan deposit and compacted fills consisting mainly of silty sand, slightly silty sand, fine to coarse sand and fine sandy silt soils	200	33.0	150	28.0
Lacustrine deposit consisting mainly of clay, silty clay, sandy clay, clayey silt and silt soils	820	15.5	330	13.5

5. Coefficient of Subgrade Reaction

The recommended coefficients of subgrade reactions for the soils at the site, on the basis of laboratory test results are presented on the following page.

	Recommended Subgrade Reaction Pounds Per Square Inch per Inch of Deflection			
	Vertical		Horizontal	
	Field Moisture Condition	Submerged Condition	Field Moisture Condition	Submerged Condition
Alluvial fan deposit and compacted non-expansive fill	320.0	160.0	64.0	32.0
Lacustrine deposit	64.0	32.0	13.0	6.5

6. Allowable Maximum Passive Resistance of Soils

Assuming that the failure of the isolated pier footings will be governed by the soil strength at the time of failure, the recommended maximum passive resistances of soils at various depths below final ground surface and/or mudline, are presented below:

Depth Below Final Ground Surface (Feet)	Allowable Maximum Passive Resistance of Soils, Kips/Sq.Ft. Alluvial Fan Deposit	Lacustrine Soil Deposit
0	0.37	1.04
1	0.56	1.13
5	1.35	1.48
10	2.33	1 91
15	3.31	2.34
20 *	4.29	2.78
25	4.84	2.89
30	5.40	3.01
35	5.95	3.12
40	6.51	3.24

* Assuming ground water or saturated soil zone will be at a depth of 20 feet below final ground surface.

The failure of isolated pier foundation may sometimes be governed by the pier structure itself or the degree of soil structure interaction below ground surface. The degree of soil structure interaction, in turn, will depend on the restrained condition or the allowable deflection condition of the pier foundation at ground surface level.

7. Uplift Resistance of Pier

To estimate the ultimate uplift resistance of an isolated belled pier, the contributory components of the resistance may be assumed to equal the combined weight of the footing plus the inverted cone of a soil prism. The inverted cone of the soil prism is defined by an imaginary plane projected upwardly and outwardly from the bottom of the footing at an inclined angle with the vertical equal to the tested angle of internal friction presented in Section (4), Page 12. The unit weight of the soils may be computed from the values shown in columns 7 and 8 of Drawing Nos. 2 to 44, inclusive.

The ultimate uplift resistance of a straight cylindrical pier may be assumed to be one-half of the downward supporting capacity of the pier as maximum, computed from the skin friction values described in Section (3), Page 10.

8. Estimated Total Settlement Under Building Foundations, the Transformer and the Oil Circuit Breaker Supporting Pad.

Assuming that the stressed bearing soils will be saturated sometime in the future, the estimated total settlement of shallow building foundations are presented below:

(A) Building Foundations

1. Building foundations on medium firm to very firm undisturbed surface of alluvial fan deposit:

	Estimated Maxumum Settlement in Inches					
	Continuous Footing			Square Footing		
Footing Width (Feet)	Unit Bearing Pressure of 2000 psf	Unit Bearing Pressure of 4000 psf	Unit Bearing Pressure of 6000 psf	Unit Bearing Pressure of 2000 psf	Unit Bearing Pressure of 4000 psf	Unit Bearing Pressure of 6000 psf
1	0.08	0.09	0.10	--	--	--
2	0.14	0.15	0.19	0.10	0.12	0.14
3	0.19	0.21	0.25	0.14	0.15	0.19
4	0.23	0.26	0.31	0.17	0.19	0.23
5	0.26	0.29	0.35	0.19	0.22	0.26
6				0.21	0.24	0.29
7				0.23	0.26	0.31
8				0.25	0.28	0.33

2. Building foundation on medium firm to very firm undisturbed surface of lacustrine deposit such as clayey silt or silt soils:

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Estimated Total Settlement in Inches

Footing Width (Feet)	Continuous Footing Unit Foundation Pressures of 1500 psf	Continuous Footing Unit Foundation Pressure of 3000 psf	Continuous Footing Unit Foundation Pressure of 5000 psf	Square Footing Unit Foundation Pressures of 1500 psf	Square Footing Unit Foundation Pressures of 3000 psf	Square Footing Unit Foundation Pressures of 5000 psf
1	0.11	0.14	0.21	--	--	--
2	0.21	0.27	0.41	0.15	0.19	0.30
3	0.30	0.38	0.58	0.21	0.28	0.42
4	0.38	0.49	0.74	0.27	0.36	0.54
5	0.44	0.57	0.88	0.32	0.42	0.64
6				0.37	0.48	0.73
7				0.41	0.53	0.80
8				0.44	0.57	0.87

Where expansive silty clay, clay or sandy clay soils are exposed on the proposed finished grades in the cut area, the upper 3 feet of expansive soils below finished grades should be replaced with a uniformly compacted filled ground consisting of non-expansive or slightly expansive soils such as silty sand, slightly silty sand and fine to coarse sand soils. The anticipated total settlement of footings on a compacted fill ground, uniformly compacted to at least 90 percent of the maximum dry density, is estimated to be less than 1/2 inch for continuous footings less than 4 feet in width and for square footings less than 7 feet in width.

(B) Settlement of Transformer and Oil Circuit Breaker Pad

Assuming that (a) the soils beneath the pad will be saturated sometime in the future, and (b) the pad will be structurally rigid, the estimated total settlements of the pad supporting transformer and oil circuit breaker are presented below:

1. Pad on medium firm to very firm undisturbed alluvial fan deposit or compacted non-expansive filled ground

Size of Pad (Width x Length in feet)	Unit Pressure At Bottom of Pad, psf	Estimated Total Settlement, Inches
15 x 20	2500	0.39
15 x 25	2500	0.31

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2. Pad on medium firm to very firm undisturbed lacustrine deposit:

Size of Pad Width x Length in feet	Unit Pressure At Bottom of Pad, psf	Estimated Total Settlement, Inches
15 x 20	2500	1.9
15 x 25	2000	1.6

For pad of smaller size or pad of less applied unit pressure, the total settlement will be less than those presented above.

9. Combined Sections of Asphaltic Concrete Pavement

Using a CBR value of 10.5 tested on the representative non-expansive subgrade soils, the required thicknesses of asphaltic concrete pavement to support various wheel loads are presented below:

	Required Thickness, Inches	
	Parking Area	Driveway Area
Design Wheel Loads in Pounds	12,000	16,000
(a) A.C. paving surface, inches	2.0	2.5
(b) Base course materials with minimum CBR of 80 at 95 percent relative compaction or Caltran's Class 2 aggregate	4.0	6.0
(c) Clay-free on-site soils or selected non-expansive import soils uniformly compacted to at least 95 percent of maximum dry density, inches	12.0	12.0

During construction, the proposed paved area should be excavated to a depth equivalent to the combined total of the thicknesses indicated on lines (a), (b) and (c). If expansive clay, silty clay or sandy clay soils are encountered, these should be disposed of off site and be replaced with select non-expansive fill soils for compaction. The exposed surface should then be scarified to a depth of 6 inches, moistened or dried, as necessary to an optimum moisture

Project No. 80-9-10A

content, and uniformly compacted to at least 90 percent of the maximum dry density. Thereafter, the excavated on-site soils and the base course materials should be placed and uniformly compacted to the required percentages of relative compaction and thicknesses indicated above.

The recommended gradation for the base course materials are as follows:

U.S. Standard Sieve Size	Percentage Passing By Weight
1"	100
3/4"	90 to 100
No. 4	35 to 55
No. 30	10 to 30
No. 200	2 to 9

10. Site Grading

It is recommended that the earthwork operations at the site be conducted under a continuous observation by a soils engineer and in accordance with the applicable sections of the attached Appendix AA entitled "Standard Specifications For The Placement Of Compacted Filled Ground."

The maximum dry density of soils to be compacted shall be obtained by the ASTM D1557-70 method of compaction that requires 25 blows of a 10 pound rammer falling from a height of 18 inches on each of 5 layers in a 4-inch diameter 1/30 cubic foot compaction mold.

11. Possible Subsurface Problems Associated with Installation of Drilled and Cast-in-Place Concrete Piers

In drilling Boring 21 using a rotary bucket drill rig, extensive caving of the boring wall occurred. The caving is attributed to the dry nature of the desert soils and is expected to occur during pier construction in the future. The dry desert soils would require pre-drilling stabilization or moistening with water before drilling.

Respectfully submitted,

BENTON ENGINEERING, INC.

By S.H. Shu
S.H. Shu, Civil Engineer
RCE No. 19913

Distribution: (5) Addressee

SHS/jr

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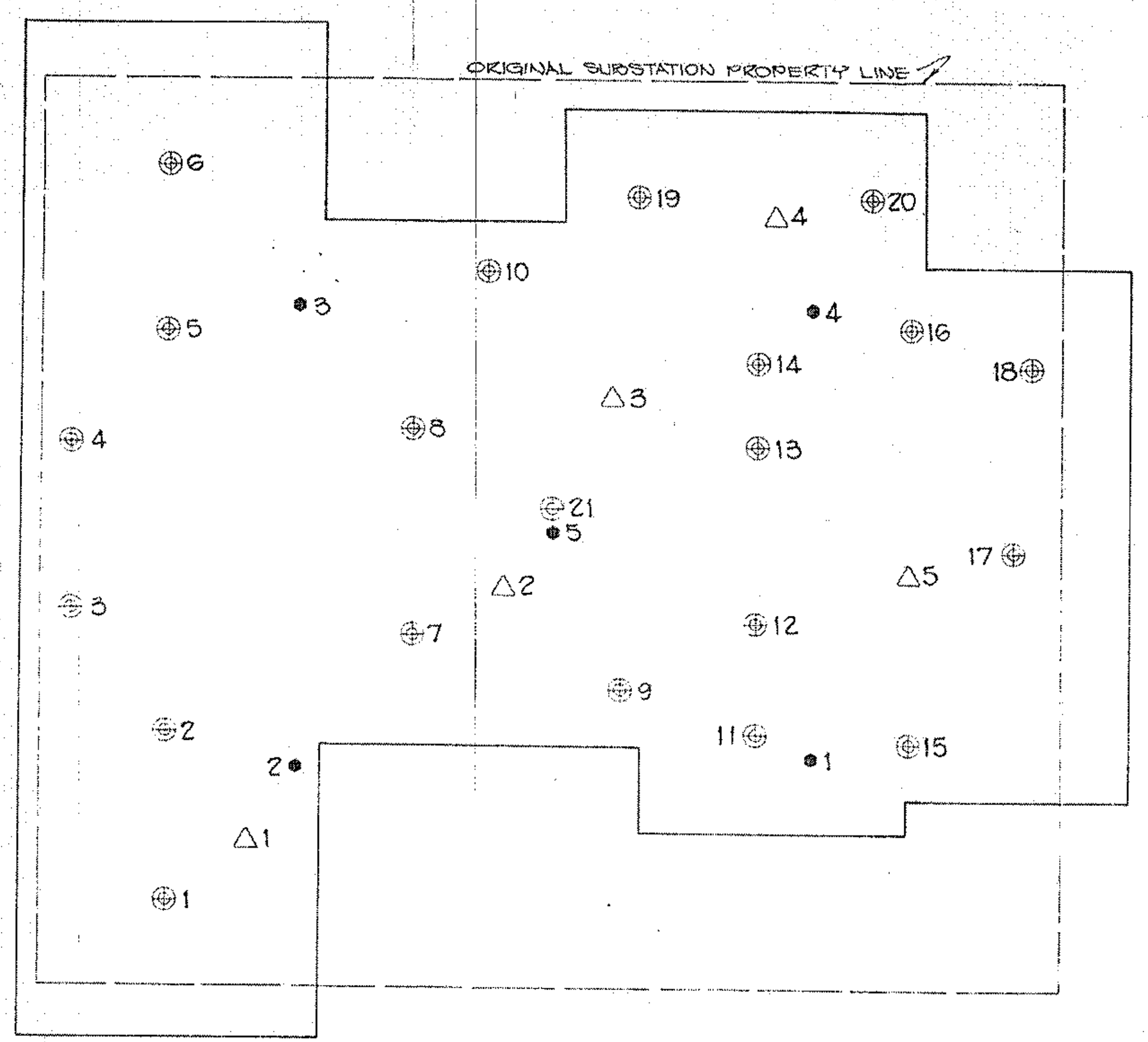

LEGEND

- ⊕ Indicates Approximate Location Of Test Boring
- △ Indicates Approximate Location Of CBR Sample
- ● Indicates Approximate Location Of Test Boring, Drilled By Fugro Inc.

BENTON ENGINEERING, INC.
SAN DIEGO, CALIFORNIA

LOCATION OF TEST BORINGS AND CBR SAMPLES

PROPOSED IMPERIAL VALLEY SUBSTATION
PHASE III, SITE 7A
IMPERIAL COUNTY, CALIFORNIA

SCALE: 1" = 200' DRAWN: K. L. Green DATE: 10-30-1980	PROJECT NO. 80-9-10A	DRAWING NO 1

SUMMARY SHEET

BORING NO. 1

ELEVATION 5.56' (*)

DEPTH/FEET	SAMPLE NUMBER	SOIL DESCRIPTION	SOIL CLASSIFICATION	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq. Ft.
0–1.7		Light Brown, Dry, Very Loose	SILTY FINE TO MEDIUM SAND					
2	1	Gray Brown, Dry, Loose, With Scattered Fine Gravel	SLIGHTLY SILTY FINE TO MEDIUM SAND	12.8	2.6	112.3	0.43	--
3	4 / 8 / 21							
5	2			15.0	11.4	99.1	0.63	--
5–7	10 / 18 / 21	Light Brown, Dry, Firm Merges	SILTY FINE SAND					
7–8.5		Olive Gray Brown, Dry, Medium Firm to Firm	FINE SANDY SILT					
8.5	8 / 10 / 24	Light Brown, Dry, Very Firm	SILTY FINE TO MEDIUM SAND					
10	3			33.0	5.4	112.0	1.38	1.23
11.5	18 / 25 / 30							
15	4			30.0	4.3	109.1	1.87	1.78

Continued on Drawing No. 3

○ Indicates Undisturbed Drive Sample

5 NR Indicates Sample Not Recovered

12 / 18 / 21 Indicates the Blowcount of a Standard Splitspoon Sampler for each 6" of Penetration 0" to 6", 6" to 12" and 12" to 18". The Standard Penetration Resistance is based on adding the number of blows between 6" and 12" to the blows between 12" and 18"

* The Elevations were provided by San Diego Gas & Electric

Imperial Valley Substation - San Diego G & Electric

PROJECT NO. 80-9-10A | BENTON ENGINEERING, INC. | DRAWING NO. 2

SUMMARY SHEET

BORING NO. 1 Cont.

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	DESCRIPTION	CLASSIFICATION	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq. Ft.
16–19	25 21 24		Olive Gray Brown, Dry, Firm, Micaceous, Small Calcareous Lenses and Scattered Lenses of Clay	SILTY FINE TO MEDIUM SAND					
19–21	5		Gray Brown, Dry, Very Dense, With Fine Gravel Merges	FINE TO COARSE SAND	30.0	16.0	110.0	3.27	--
21–24	16 16 24		Gray Brown, Dry, Dense, With Scattered Coarse Sand Grains and Fine Gravel	SLIGHTLY SILTY FINE TO MEDIUM SAND					
24–26	6	Water	Saturated Very Dense		40.5	13.0	123.6	4.32	--
26–30	15 32 48 7		Light Brown, Saturated, Very Dense	SLIGHTLY SILTY FINE SAND	67.5	17.7	106.7	3.26	--

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	3

JOB NAME Imperial Valley Substation - San Diego Gas Electric

SUMMARY SHEET

BORING NO. 2

ELEVATION 7.68'

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	Description	Classification	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq. Ft.
0–1			Light Brown, Dry, Very Loose	SILTY FINE TO MEDIUM SAND					
2–3	1; 6, 14, 18		Gray Brown, Dry, Very Loose, With Sea Shell Fragments and Scattered Fine Gravel	SLIGHTLY SILTY FINE TO COARSE SAND	11.3	13.1	98.4	0.32	0.28
4–5	2 NR		Light Brown and Light Gray Brown, Dry, Medium Firm, With Lenses of Silty Fine To Medium Sand and Slightly Silty Fine to Coarse Sand	SILTY FINE SAND	15.0	--	--	--	--
5–7	6, 11, 17		Light Brown and Gray Brown, Dry, Medium Firm, With Lenses of Silty Fine Sand	SILTY FINE TO MEDIUM SAND					
8	8, 17, 28		With Lenses of Clayey Silt						
10	3		Firm		19.5	8.6	106.1	1.41	1.22
11–12	15, 25, 27		Very Firm						
14–15	4 NR		With Thin Lens of Clayey Silt; Merges		45.0	--	--	--	--
16–17	23, 32, 50		Light Brown, Dry, Very Dense	SLIGHTLY SILTY FINE TO MEDIUM SAND					
18–21	5		Light Brown, Dry, Very Firm	SILTY FINE TO MEDIUM SAND	34.5	4.6	105.2	2.35	1.83

Continued on Drawing No. 5

PROJECT NO. 80-9-10A

BENTON ENGINEERING, INC.

DRAWING NO. 4

JOB NAME Imperial Valley Substation - San Diego Gas Electric

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SUMMARY SHEET

BORING NO. 2 Cont.

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL			DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq. Ft.
21–23	16 22 26		Olive Gray Brown, Moist, Firm, Micaceous	SILTY FINE SAND					
23–25	6		Light Gray Brown, Very Moist, Very Dense	FINE TO COARSE SAND	30.0	15.9	113.4	5.39	--
25–30	15 30 48, 7		Light Brown, Very Moist, Very Firm	SILTY FINE TO MEDIUM SAND	51.0	19.9	103.1	3.18	--

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	5

Imperial Valley Substation - San Diego Gas Electric

JOB NAME

SUMMARY SHEET

BORING NO. 3

ELEVATION 8.21'

Sample Number	Description	Soil Classification	Drive Energy Ft. Kips/Ft.	Field Moisture % Dry Wt.	Dry Density Lbs./Cu. Ft.	Shear Resistance Kips/Sq. Ft.	Sat. Shear Kips/Sq. Ft.
	Gray Brown, Dry, Loose, With Shell Fragments	SILTY FINE TO MEDIUM SAND					
1 / 11 16 19	Firm		18.8	19.3	98.2	0.36	--
2 NR / 11 20 25	Light Brown, Dry, Medium Firm to Firm, Slightly Micaceous; Merges	SILTY FINE SAND	15.8	--	--	--	--
6 10 14	Gray Brown, Dry, Medium Firm, Interbedded with Silty Fine Sand	FINE SANDY SILT					
3			27.8	11.4	103.4	1.42	0.85
18 35 48	Light Brown, Dry, Dense to Very Dense, With Lenses of Fine Sand	SLIGHTLY SILTY FINE TO MEDIUM SAND					
4 / 11 22 40	Olive Gray, Dry, Medium Firm, Micaceous, Thinly Bedded	FINE SANDY SILT	13.5	15.6	82.1	1.78	0.73
	Light Brown, Dry, Very Dense	SLIGHTLY SILTY FINE SAND					
5	Light Brown, Dry, Very Dense	SLIGHTLY SILTY FINE TO MEDIUM SAND	60.0	13.0	106.6	2.51	2.16

Continued on Drawing No. 7

PROJECT NO. 80-9-10A

BENTON ENGINEERING, INC.

DRAWING NO. 6

Imperial Valley Substation - San Diego Gas & Electric

SUMMARY SHEET

BORING NO. 3 Cont.

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	DESCRIPTION	SOIL	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS/CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq. Ft.
20–23	18 28 33		Light Brown, Dry, Very Firm	SILTY FINE TO MEDIUM SAND					
23–26	6		Light Brown, Moist, Very Firm, With Small Calcareous Nodules	SILTY FINE SAND	39.0	7.6	105.7	2.70	2.42
26–29	12 20 34		Olive Gray Brown, Micaceous	SILTY FINE SAND					
29–30	7	Water	Saturated	SILTY FINE SAND	22.5	20.5	107.3	3.38	--

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	7

JOB NAME Imperial Valley Substation - San Diego Gas & Electric

SUMMARY SHEET

BORING NO. 4

ELEVATION 9.51'

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	DESCRIPTION	CLASSIFICATION	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS/CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq. Ft.
0–1			Gray Brown, Dry, Very Loose	SILTY FINE TO MEDIUM SAND					
1–2.5	1		Firm Merges		15.0	1.1	98.7	0.23	--
2.5–4	7 / 13 / 17		Light Gray Brown, Dry, Firm	SILTY FINE SAND					
4–8.5	2 NR 14 / 16 / 20				21.8	--	--	--	--
8.5–11.5	9 / 16 / 20 3		Lenses of Silty Fine to Medium Sand		24.0	3.7	112.0	1.49	1.22
11.5–12.5	8 / 15 / 21		Thin Lens of Fine Sandy Silt, Micaceous						
12.5–13			No Sandy Silt						
13–16	4 NR		Light Brown, Dry, Very Dense	SLIGHTLY SILTY FINE SAND	42.0	--	--	--	--
16–19	19 / 28 / 36		Light Brown, Dry, Very Dense	SLIGHTLY SILTY FINE TO MEDIUM SAND					
19–20	5		Light Brown, Dry, Very Dense	SLIGHTLY SILTY FINE SAND	34.5	11.9	102.9	2.70	2.40

Continued on Drawing No. 9

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	8

SUMMARY SHEET

BORING NO. 4 Cont.

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL			DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq. Ft.
20–23	15 30 43		Light Brown, Dry Very Dense	SLIGHTLY SILTY FINE SAND					
23–24.5			Gray Brown, Dry, Very Firm	SILTY FINE TO MEDIUM SAND					
24.5–26.5	6 NR		Gray Brown, Dry, Very Dense, With Fine Gravel	FINE TO COARSE SAND	45.0	--	--	--	--
26.5–28.5	13 22 31		Gray Brown, Slightly Moist, Very Dense, With Fine Gravel	SLIGHTLY SILTY FINE TO COARSE SAND					
28.5–30.5	7		Red Brown and Light Brown, Very Moist to Saturated, Very Firm, With Lenses of Fine to Medium Sand	SILTY CLAY	45.0	18.2	107.8	3.07	--
30.5–38.5	18 33 50 / 8 / 26 47 59		Light Brown, Very Moist, Very Dense	FINE TO MEDIUM SAND	64.5	20.9	101.3	3.57	--
38.5–40	9		Thin Lens of Silty Fine to Medium Sand		75.0	17.2	99.1	3.32	--

Continued on Drawing No. 10

JOB NAME Imperial Valley Substation - San Diego Gas . Electric

PROJECT NO. 80-9-10A

BENTON ENGINEERING, INC.

DRAWING NO. 9

JOB NAME Imperial Valley Substation - San Diego Gas & E..ctric

SUMMARY SHEET

BORING NO. 4 Cont.

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	Description	Classification	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips. Sq. Ft.
40–46	30, 42, 65 (41–42); 10 (45)		Light Brown, Very Moist, Very Dense, With Lenses of Slightly Silty Fine Sand	SLIGHTLY SILTY FINE TO MEDIUM SAND	52.5	18.9	102.5	3.47	--
46–47	15, 26		With Thin Lenses of Clay						
47–50	26 (47); 11 (50)		Red Brown to Light Brown, Saturated, Very Firm, With Scattered Thin Lenses of Slightly Silty Fine to Medium Sand	SILTY CLAY	27.0	23.1	104.0	3.62	--

PROJECT NO. 80-9-10A

BENTON ENGINEERING, INC.

DRAWING NO. 10

JOB NAME Imperial Valley Substation - San Diego Gas Electric

SUMMARY SHEET

BORING NO. 5

ELEVATION 9.99'

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	DESCRIPTION	SOIL	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
0–1			Light Brown and Gray Brown, Dry, Very Loose	SILTY FINE TO MEDIUM SAND					
1–4	1 9 15 24		Medium Firm, With Lenses of Fine to Medium Sand and Silty Fine Sand and Scattered Shell Fragments		18.0	9.1	99.6	0.36	--
4–10.5	2 17 28 35		Gray Brown, Dry, Very Firm, With Scattered Lenses of Fine to Medium Sand	SILTY FINE SAND	19.5	2.9	97.4	0.56	--
	14 20 35								
	3 NR				47.3	--	--	--	--
10.5–13	9 12 16		Gray Brown, Dry, Medium Firm, With Lenses of Clayey Silt	FINE SANDY CLAY					
13–14.5			Gray Brown, Dry, Firm	SILTY FINE TO MEDIUM SAND					
14.5–19	4		Very Firm		49.5	5.3	108.8	1.94	1.53
	25 33 38								
19–20	5		Light Brown		37.5	2.4	107.4	2.65	2.17

Continued on Drawing No. 12

JOB NAME Imperial Valley Substation - San Diego Ga[illegible] Electric

SUMMARY SHEET

BORING NO. 5 (Cont.)

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	DESCRIPTION	CLASSIFICATION	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq. Ft.
20–25	15 25 30 (21–22); 6 (25)		Gray Brown, Dry, Very Firm	SILTY FINE TO MEDIUM SAND	39.0	16.7	109.5	4.11	--
25–28	17 26 30 (26–27)		Gray Brown, Dry, Very Dense, With Lenses of Fine to Coarse Sand, With Fine Gravel	SLIGHTLY SILTY FINE TO MEDIUM SAND					
28–30	7 (30)		Light Gray Brown, Slightly Moist, Very Dense, With Lenses of Fine to Coarse Sand, With Fine Gravel	FINE TO MEDIUM SAND	46.5	14.5	106.3	3.85	--

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	12

SUMMARY SHEET

BORING NO. 6

ELEVATION 10.60'

DEPTH/FEET	SAMPLE NUMBER	DESCRIPTION	SOIL CLASSIFICATION	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS/CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
0		Light Brown, Dry, Loose	SILTY FINE TO MEDIUM SAND					
2	1 (9, 10, 15)	Gray Brown, Dry, Loose, With Fine to Medium Gravel	FINE TO COARSE SAND	12.0	6.6	99.7	0.47	--
3		Firm						
5	2 (14, 20, 28)	Gray Brown, Dry, Firm, With Lenses of Fine Sandy Silt and Silty Fine to Medium Sand	SILTY FINE SAND	21.0	1.0	106.1	0.49	--
8	(10, 20, 30)	Gray Brown, Slightly Moist, Firm	CLAYEY FINE SAND					
10	3 NR	Gray Brown, Dry, Very Firm	SILTY FINE TO MEDIUM SAND	42.0	--	--	--	--
11	(23, 30, 40)	Light Brown, With Lenses of Silty Fine Sand						
15	4 (14, 20, 25)	No Lenses of Silty Fine Sand		46.5	1.9	105.7	1.59	--
20	5 NR	Gray Brown, Dry, Firm, With Fine to Medium Gravel	SILTY FINE TO COARSE SAND	24.0	--	--	--	--

Continued on Drawing No. 14

JOB NAME Imperial Valley Substation - San Diego Gas Electric

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	13

SUMMARY SHEET
BORING NO. 6 (Cont.)

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	DESCRIPTION		DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
20–24	12 17 22		Light Gray Brown, Dry, Firm, With Fine Gravel	SILTY FINE TO COARSE SAND					
24–28	6 18 23 35		Light Gray Brown, Dry, Very Firm, With Fine Gravel	SLIGHTLY SILTY FINE TO COARSE SAND	45.0	17.4	108.1	3.81	--
28–30	7		Brown, Slightly Moist, Firm, Slightly Micaceous	CLAYEY FINE SAND	56.3	14.8	106.6	3.84	--

JOB NAME Imperial Valley Substation - San Diego G & Electric

PROJECT NO. 80-9-10A

BENTON ENGINEERING, INC.

DRAWING NO. 14

JOB NAME Imperial Valley Substation - San Diego Gas . Electric

SUMMARY SHEET

BORING NO. 7

ELEVATION 5.18'

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	DESCRIPTION	CLASSIFICATION	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
0–2			Brown and Gray Brown, Dry, Very Loose, With Scattered Medium Gravel	SILTY FINE TO MEDIUM SAND					
2	1; 9, 18, 22		Brown and Gray Brown, Dry, Firm ti Very Firm, Micaceous	SILTY FINE SAND	15.0	6.6	98.1	0.36	0.36
4–5	2 NR		With Scattered Shell Fragments		19.5	--	--	--	--
5–11	18, 24, 28; 17, 17, 19; 3		Gray Brown and Brown, Dry, Very Firm	SILTY FINE TO MEDIUM SAND	24.0	3.1	106.0	1.50	1.04
11–13	10, 13, 15		Gray Brown, Dry, Dense	SLIGHTLY SILTY FINE TO MEDIUM SAND					
13–20	4 NR; 11, 15, 18		Gray Brown and Light Gray, Dry, Dense, With Scattered Fine Gravel	FINE TO COARSE SAND	21.8	--	--	--	--
20–21	5		Brown, Dry, Very Firm	SILTY FINE TO MEDIUM SAND	36.0	6.3	108.3	2.40	1.96

Continued on Drawing No. 16

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	15

JOB NAME Imperial Valley Substation - San Diego G. & Electric

SUMMARY SHEET

BORING NO. 7 (Cont.)

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	DESCRIPTION	SOIL	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
21–24	14 / 20 / 30		Light Brown, Dry to Slightly Moist, Very Dense	SLIGHTLY SILTY FINE SAND					
24–26	6		Very Moist		36.0	13.7	98.6	2.53	--
26–30	16 / 24 / 35; 7		With Scattered Lime Cemented Nodules		67.5	20.7	103.1	3.09	--

PROJECT NO. 80-9-10A

BENTON ENGINEERING, INC.

DRAWING NO. 16

JOB NAME Imperial Valley Substation - San Diego Gas & Electric

SUMMARY SHEET

BORING NO. 8

ELEVATION 8.91'

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	DESCRIPTION	CLASSIFICATION	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS/CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
0–1			Gray Brown and Brown, Dry, Very Loose	SILTY FINE TO MEDIUM SAND					
1–2.5	1		Medium Firm, With Scattered Medium Gravel		13.5	5.1	102.3	0.26	0.12
2.5–5	9 / 15 / 18; 2 NR		Gray Brown, Dry, Medium Firm, With Lenses of Silty Fine to Medium Sand	SILTY FINE SAND	24.0	--	--	--	--
5–8	15 / 35 / 45		Gray Brown, Dry, Very Firm	SILTY FINE TO MEDIUM SAND					
8–13	12 / 13 / 15; 3 NR; 11 / 14 / 16		Firm		21.0	--	--	--	--
13–16	4 NR		Gray Brown, Dry, Dense to Very Dense, With Fine to Medium Gravel	SLIGHTLY SILTY FINE TO COARSE SAND	22.5	--	--	--	--
16–18	26 / 29 / 42		Light Brown, Dry, Very Firm	SILTY FINE TO MEDIUM SAND					
18–20	5		Light Brown, Dry, Very Firm	SILTY FINE SAND	52.5	9.0	98.9	1.99	1.74

Continued on Drawing No. 18

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	17

SUMMARY SHEET

BORING NO. 8 (Cont.)

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL			DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
20–23	25 / 48 / 62 (21–22)		Light Brown, Dry, Very Firm, With Lenses of Slightly Silty Fine Sand	SILTY FINE SAND					
23–25.5	6 (25)		Red Brown, Moist to Very Moist, Very Firm, With Scattered Lime Cemented Nodules	CLAY	37.5	20.5	105.1	5.44	--
25.5–29	25 / 40 / 62 (26–27)		Gray Brown, Slightly Moist, Very Dense	SLIGHTLY SILTY FINE SAND					
29–30	7 (30)		Very Moist		71.3	23.6	98.0	3.81	--

JOB NAME Imperial Valley Substation - San Diego Ga[illegible] Electric

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	18

SUMMARY SHEET

BORING NO. 9

ELEVATION 1.64'

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL			DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS/CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
0, 1			Brown, Dry, Firm	CLAYEY SILT					
2, 3	1 (14, 18, 22)		Very Firm		25.5	3.0	89.9	0.32	--
4, 5, 6, 7, 8	2 (12, 14, 30); 13, 16, 16		With Lenses of Silty Clay and Silt, and Scattered Caliche Pods		16.5	14.6	98.8	2.23	--
9, 10, 11	3		Red Brown, Slightly Moist, Very Firm, With Thin Lenses of Clayey Silt	CLAY	13.5	20.2	106.4	3.26	--
12	10, 15, 40		Brown, Dry, Very Firm, Thinly Bedded With Scattered Lenses of Silty Clay	SILT					
13, 14, 15	4		Red Brown, Slightly Moist, Very Firm, Contains Cracks, With Thin Lenses of Silt, Loss of Water Circulation During Drilling	CLAY	22.5	20.5	103.6	1.37	--
16, 17, 18, 19, 20	15, 20, 20; 5		Brown and Gray Brown, Slightly Moist, Very Firm, Thinly Bedded, With Scattered Lenses of Fine Sandy Silt and Silty Clay	SILT	32.3	21.9	97.5	0.84	--

Continued on Drawing No. 20

Note: Used Unconfined Compression Test Data Figure Divided by 2 for Shear Resistance Figure on Sample No. 3,4 and 5.

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	19

JOB NAME Imperial Valley Substation - San Diego Gas & Electric

SUMMARY SHEET

BORING NO. 9 (Cont.)

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	DESCRIPTION		DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq. Ft.
20–22	13 15 28		Brown and Gray Brown, Moist, Firm, With Lenses of Silty Clay and Silty Fine Sand	FINE SANDY SILT					
22–24			Very Moist						
24–25	6	Water	Saturated		30.0	27.2	96.2	3.10	--
26–27	12 12 12								
30	7		Lenses of Silty Clay		42.0	26.0	98.8	2.90	--

JOB NAME Imperial Valley Substation – San Diego Gas & Electric

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	20

SUMMARY SHEET

BORING NO. 10

ELEVATION 8.95'

DEPTH/FEET	SAMPLE NUMBER	DESCRIPTION	SOIL	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS/CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
0–1.5		Gray Brown, Dry, Very Loose, With Scattered Fine to Medium Gravel	SLIGHTLY SILTY FINE TO COARSE SAND					
1.5–3.5	1; 9, 10, 12	Medium Dense		10.5	1.4	108.2	0.39	--
3.5–5	2 NR	Gray Brown, Dry, Medium Firm	SILTY FINE TO MEDIUM SAND	12.8	--	--	--	--
5–9	8, 9, 11; 8, 9, 20	Gray Brown, Dry, Medium Dense Merges	SLIGHTLY SILTY FINE TO COARSE SAND					
9–14	3; 11, 17, 23	Brown to Light Brown, Dry, Firm to Very Firm	SILTY FINE TO MEDIUM SAND	34.5	2.8	108.7	1.16	--
14–16	4	Red Brown, Dry, Very Firm, With Clay Lenses and Lime Cemented Lenses	FINE SANDY SILT	34.5	9.2	89.0	1.27	1.06
16–18.5	20, 32, 40	Light Brown to Light Gray Brown, Dry, Very Firm, Inter-bedded with Fine Sandy Silt	SLIGHTLY SILTY FINE SAND					
18.5–20	5	Light Brown, Dry, Very Firm, Thinly Bedded	FINE SANDY SILT	45.0	6.9	98.1	2.18	--

Continued on Drawing No. 22

JOB NAME Imperial Valley Substation - San Diego Gas & Electric

PROJECT NO. 80-9-10A

BENTON ENGINEERING, INC.

DRAWING NO. 21

Imperial Valley Substation - San Diego Gas & Electric

JOB NAME

SUMMARY SHEET

BORING NO. 10 (Cont.)

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	Description	Classification	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
20–21.5			Light Brown, Dry to Slightly Moist, Very Firm, With Lenses of Silty Fine Sand	FINE SANDY SILT					
21.5–24	14 16 26		Red Brown, Moist, Very Firm	CLAY					
24–25	6		Red Brown, Moist, Very Firm	FINE SANDY SILT	33.0	2.1	101.3	2.56	--
25–27.5	7 11 14		Red Brown, Very Moist, Very Firm, With Lenses of Silty Clay and Clayey Silt	CLAY					
27.5–28			Medium Firm	CLAY					
28–30	7		Light Brown to Brown, Very Moist, Very Firm With Lenses of Silty Fine Sand	FINE SANDY SILT	45.0	25.2	91.1	2.66	--

PROJECT NO. 80-9-10A

BENTON ENGINEERING, INC.

DRAWING NO. 22

SUMMARY SHEET

BORING NO. 11

ELEVATION -1.44'

Depth/Feet	Sample Number	Soil Description	Soil Classification	Drive Energy Ft. Kips/Ft.	Field Moisture % Dry Wt.	Dry Density Lbs./Cu. Ft.	Shear Resistance Kips/Sq. Ft.	Sat. Shear Kips/Sq. Ft.
0–1		Red Brown and Light Brown, Dry, Firm to Very Firm, Merges	CLAYEY SILT					
2–5	1 (40, 50, 55)	Red Brown and Light Brown, Dry Firm to Very Firm, With Thinly Bedded Lenses of Silt and Clay	SILTY CLAY	63.8	7.9	116.4	3.64	--
	2			44.3	15.8	98.8	1.18	--
6–7	(23, 28, 40)	Gray Brown, Dry, Very Firm, Thinly Bedded	SILT					
8–9	(10, 14, 23)	Brown and Red Brown, Slightly Moist, Very Firm, With Lenses of Clayey Silt Merges	SILTY CLAY					
10–13	3 (11, 16, 23)	Red Brown, Slightly Moist, Very Firm, With Scattered Lenses of Clayey Silt	CLAY	22.5	18.4	106.0	3.00	--
14–18	4 (16, 19, 18)	Light Brown and Yellow Brown, Dry, Very Firm, Thinly Bedded, With Scattered Lenses of Fine Sandy Silt	SILT	24.8	6.4	99.5	0.75	--
19–20	5	Light Brown, Dry to Slightly Moist, Very Firm, Thin Bedding	SILTY FINE SAND	39.0	6.6	88.4	2.23	--

Continued on Drawing No. 24

Note: Used Unconfined Compression Test Data Figure Divided By 2 for Shear Resistance Figure On Sample No. 1,2,3 and 4.

JOB NAME Imperial Valley Substation - San Diego Gas & Electric

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	23

JOB NAME Imperial Valley Substation - San Diego (, & Electric

SUMMARY SHEET

BORING NO. 11 (Cont.)

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	DESCRIPTION		DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
20–23	12 16 23		Light Brown, Dry to Slightly Moist, Very Firm, Thin Bedding Merges	SILTY FINE SAND					
			Brown and Light Brown, Moist, Firm	FINE SANDY SILT					
23–25	6		Light Brown, Very Moist to Saturated, Very Firm, With Scattered Lenses of Clayey Silt	SILTY FINE SAND	40.5	23.8	99.2	2.62	--
25–30	15 15 15	Water	Saturated						
	7				40.5	23.3	102.9	3.21	--
30									

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	24

Imperial Valley Substation - San Diego G... & Electric

JOB NAME

SUMMARY SHEET

BORING NO. 12

ELEVATION -0.36'

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	DESCRIPTION		DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
0–1			Red Brown, Dry, Loose	CLAYEY SILT					
			Merges						
1–7	1 (20, 50, 70)		Brown and Red Brown, Dry, Firm to Very Firm, With Thin Lenses of Silt	SILTY CLAY	25.5	13.2	106.8	2.13	--
	2 (18, 33, 38)				22.5	6.8	94.0	5.19	--
7–9.7	13, 14, 21		Light Brown, Dry, Firm to Very Firm, Thinly Bedded	SILT					
	3				24.0	12.7	104.9	2.43	--
9.7–13	12, 20, 28		Red Brown, Moist, Very Firm	CLAY					
13–20	4		Brown and Yellow Brown, Dry, Very Firm, Interbedded with Fine Sandy Silt, Thinly Bedded	SILT	31.5	10.1	97.3	0.67	--
	18, 30, 30								
	5		With Scattered Lenses of Silty Clay		22.5	21.0	104.6	1.04	--

Continued on Drawing No. 26

Note: Used Unconfined Compression Test Data Figure, Divided By 2 for Shear Resistance Figure On Sample No. 1,2,3,4 and 5.

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	25

Imperial Valley Substation - San Diego C . & Electric

JOB NAME

SUMMARY SHEET

BORING NO. 12 (Cont.)

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	Description		DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq. Ft.
20–24	12, 20, 21		Brown, Moist, Very Firm, With Clayey Silt and Silty Clay Lenses	SILT					
24–28	6		Very Moist to Saturated	SILT	42.0	25.7	98.1	2.95	--
	10, 14, 22								
28–30	7		Interbedded with Silty Fine Sand	SILT	42.0	25.7	96.9	2.82	--

PROJECT NO. 80-9-10A

BENTON ENGINEERING, INC.

DRAWING NO. 26

SUMMARY SHEET

BORING NO. 13

ELEVATION 0.32'

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	DESCRIPTION	CLASSIFICATION	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
0–1			Light Gray Brown, Dry, Loose	SILTY FINE TO MEDIUM SAND					
1–4.5	1; 7/14/26		Red Brown, Slightly Moist, Firm to Very Firm Dry	SILTY CLAY	12.0	14.5	99.4	2.88	--
4.5–9.5	2; 10/20/34; 17/20/25		Brown, Dry, Very Firm, Thinly Bedded, With Scattered Lenses of Silty Clay and Scattered Lime Cemented Nodules	SILT	34.5	29.8	94.0	3.23	0.47
9.5–13	3; 16/21/32		Red Brown, Moist, Very Firm, With Scattered Lime Cemented Nodules and Lenses of Clayey Silt	CLAY	24.0	24.9	100.5	1.34	--
13–19	4; 16/20/27		Light Brown, Dry, Very Firm, Thinly Bedded, With Scattered Thin Lenses of Clayey Silt and Silty Clay	SILT	27.0	24.0	100.2	1.51	1.14
19–20	5		Light Brown, Dry, Firm to Very Firm, With Scattered Lime Cemented Nodules	FINE SANDY SILT	24.8	27.6	96.4	2.25	1.58

Continued on Drawing No. 28

Note: Used Unconfined Compression Test Data Figure, Divided By 2 For Shear Resistance Figure On Sample No. 2,4 and 5.

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	27

JOB NAME Imperial Valley Substation - San Diego Gas & ...ectric

JOB NAME Imperial Valley Substation - San Diego Gas & [Electric]

SUMMARY SHEET

BORING NO. 13 (Cont.)

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	DESCRIPTION	CLASSIFICATION	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS/CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
20–21.5	7, 9, 12	Water	Light Brown, Dry, Firm to Very Firm, With Scattered Lime Cemented Nodules	FINE SANDY SILT					
21.5–23			Brown, Saturated, Medium Firm	CLAY					
23–30	6		Brown and Yellow Gray Brown, Saturated, Firm, Interbedded with Silty Clay, Thinly Bedded	CLAYEY SILT	22.5	29.8	94.0	2.81	--
	7, 15, 27								
30	7				58.5	24.9	100.5	2.98	--
30–32	23, 20, 13		Light Brown, Saturated, Dense	SLIGHTLY SILTY FINE SAND					
32–33.5			Light Brown, Saturated, Medium Firm	FINE SANDY SILT					
33.5–35	8		Brown, Saturated, Firm	SILTY FINE SAND	28.5	24.0	100.2	3.10	--
35–36.5	5, 6, 6		Brown, Saturated, Firm, Inter-bedded with Clayey Silt and Fine Sandy Silt	CLAY					
36.5–40	9		Medium Firm		19.5	27.6	96.4	2.49	--

Continued on Drawing No. 29

SUMMARY SHEET

BORING NO. 13 (Cont.)

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	DESCRIPTION		DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
40			Brown, Saturated, Medium Firm, With Scattered Lenses of Clayey Silt	CLAY					
41–42	5 7 9								
43			No Silt Below 43' Depth						
44			Brown with Light Gray Marbling						
45	10				19.5	31.5	91.8	4.41	--
46–47	5 8 9								
48									
49									
50	11				16.5	33.0	88.2	3.58	--

JOB NAME Imperial Valley Substation - San Diego Gas & Electric

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	29

SUMMARY SHEET

BORING NO. 14

ELEVATION 3.04'

Depth/Feet	Sample Number	Description	Soil Classification	Drive Energy Ft. Kips/Ft.	Field Moisture % Dry Wt.	Dry Density Lbs./Cu. Ft.	Shear Resistance Kips/Sq. Ft.	Sat. Shear Kips/Sq.Ft.
0–2		Gray Brown, Dry, Loose	GRAVELLY SILTY FINE TO MEDIUM SAND					
2–3	(1) [12] [17] [20]	Red Brown, Dry, Firm, Brittle and Fractured		10.5	10.4	97.2	1.20	--
3–5	(2)	Red Brown and Brown, Dry, Firm, Thinly Bedded, With Clayey Silt	SILT	12.8	11.4	99.4	2.09	--
5–8.5	[5] [6] [6] [4] [9] [21]	Red Brown and Brown, Dry, Firm, With Shrinkage Cracks, With Thin Lenses of Clayey Silt	CLAY					
8.5–9.5		Yellow Gray Brown, Dry, Firm	SILT					
9.5–11	(3)	Brown to Red Brown, Dry, Firm to Very Firm, With Shrinkage Cracks	CLAY	21.0	13.8	100.7	3.09	0.74
11–14.5	[14] [20] [28]	Brown, Dry, Very Firm, Thinly Bedded, With Lenses of Silt	CLAYEY SILT					
14.5–15.5	(4)	Red Brown, Moist, Very Firm, Some Shrinkage Cracks	CLAY	18.0	14.0	107.3	1.56	--
15.5–20	[16] [23] [28] (5)	Brown and Yellow Gray Brown, Dry, Very Firm, Thinly Bedded	SILT	26.3	6.9	94.9	2.56	1.66

Continued on Drawing No. 31

Note: Used Unconfined Compression Test Data Figure, Divided By 2 For Shear Resistance Figure On Sample No. 3,5 and 6.

JOB NAME: Imperial Valley Substation - San Diego [illegible] & Electric

PROJECT NO. 80-9-10A

BENTON ENGINEERING, INC.

DRAWING NO. 30

JOB NAME Imperial Valley Substation - San Diego Gas & Electric

SUMMARY SHEET

BORING NO. 14 (Cont.)

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	DESCRIPTION		DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS/CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
20–24	18, 18, 18		Brown and Yellow Gray Brown, Slightly Moist, Firm, Thinly Bedded	SILT					
24–25.5	6		Moist, Very Firm, With Thin Lenses of Silty Clay	SILT	30.0	14.3	102.3	3.81	2.13
25.5–30	5, 8, 12, 7		Brown, Very Moist to Saturated, Medium Firm, With Lenses Of Clayey Silt	SILTY CLAY	19.5	26.1	95.5	1.73	--

PROJECT NO. 80-9-10A

BENTON ENGINEERING, INC.

DRAWING NO. 31

JOB NAME San Diego Gas & Electric - Imperial Valley Su... ation

SUMMARY SHEET

BORING NO. 15

ELEVATION -1.62'

Depth/Feet	Sample Number	Soil Classification Symbol	Description	Soil	Drive Energy Ft. Kips/Ft.	Field Moisture % Dry Wt.	Dry Density Lbs./Cu. Ft.	Shear Resistance Kips/Sq. Ft.	Sat. Shear Kips/Sq.Ft.
0–1			Light Brown, Dry, Firm	SILTY CLAY					
1–4	(1) 19 36 48		Red Brown, Slightly Moist, Very Firm, With Lenses Of Silty Clay	CLAY	26.3	13.1	110.5	3.09	--
4–9	(2) 15 18 27; 14 15 28		Light Brown, Dry, Very Firm, Thinly Bedded, With Scattered Lenses Of Silty Clay and Clayey Silt	SILT	22.5	11.0	89.7	0.20	--
9–12	(3) 9 12 25		Yellow Gray Brown and Light Brown	SILT	33.0	3.7	101.2	1.21	--
12–13			Red Brown, Moist, Very Firm	CLAY					
13–16	(4)		Yellow Gray Brown, Dry, Very Firm, Thinly Bedded	FINE SANDY SILT	27.0	12.4	96.2	2.01	--
16–20	28 37 52 (5)		Light Brown, Dry, Very Firm	SLIGHTLY SILTY FINE SAND	54.0	12.1	97.5	2.04	--

Continued On Drawing No. 33

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	32

SUMMARY SHEET

BORING NO. 15 (Cont.)

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL			DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
20–24	21 32 55		Light Brown, Slightly Moist, Very Firm, Thin Bedding	SLIGHTLY SILTY FINE SAND					
25	6R		Moist		56.3	--	--	--	--
26–29	26 40 45	Water	Saturated, With Scattered Lenses of Silty Clay						
30	7				33.0	25.4	99.0	1.76	--

JOB NAME San Diego Gas & Electric - Imperial Valley Substation

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	33

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	SUMMARY SHEET BORING NO. 16 ELEVATION 0.42'		DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
0–1			Brown, Dry, Loose	CLAYEY SILT					
1–6.5	1 21 17 23 2 15 30 35		Brown, Dry, Very Firm, Interbedded With Silty Clay and Clayey Silt	SILT	21.8 24.0	4.5 9.4	107.3 96.0	3.77 3.71	-- --
6.5–9.2	12 20 38		Brown, Dry, Very Firm	SILTY CLAY					
9.2–18.4	3 16 21 24 4 14 13 25		Brown, Dry, Very Firm, Thinly Bedded, Interbedded With Lenses Of Silty Fine Sand and Silty Clay	FINE SANDY SILT	30.0 39.0	3.8 7.0	96.7 91.1	0.86 1.56	-- --
18.4–20	5		Brown, Dry, Very Firm, With Lenses Of Silty Clay	CLAYEY SILT	30.0	17.2	99.5	2.99	--

Continued On Drawing No. 35

Note: Used Unconfined Compression Test Data Figure, Divided By 2 For Shear Resistance Figure On Sample No. 1,2 and 3

JOB NAME San Diego Gas & Electric - Imperial Valley Sub[illegible]ation

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	34

JOB NAME San Diego Gas & Electric - Imperial Valley Sub. .tion

SUMMARY SHEET

BORING NO. 16 (Cont.)

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	Description	Classification	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS/CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
20–23	9 / 13 / 27		Brown, Dry, Very Firm, Thinly Bedded	SILTY CLAY					
23–29	6		Brown, Moist, Very Firm, Massive Structure	SILTY FINE SAND	67.5	5.5	96.1	2.55	---
	14 / 22 / 34								
29–30	7	Water	Saturated		33.0	23.2	101.7	2.81	---

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	35

JOB NAME San Diego Gas & Electric - Imperial Valley Substation

SUMMARY SHEET

BORING NO. 17

ELEVATION -0.48'

Depth/Feet	Sample Number	Soil Classification Symbol	Description		Drive Energy Ft. Kips/Ft.	Field Moisture % Dry Wt.	Dry Density Lbs/Cu. Ft.	Shear Resistance Kips/Sq. Ft.	Sat. Shear Kips/Sq.Ft.
0–1.5			Brown, Dry, Loose Firm to Very Firm, Thinly Laminated, Merges	SILT					
1.5–7	1 (16, 20, 27)		Brown, Dry, Firm to Very Firm, Laminated With Thin Layers of Silt	SILTY CLAY	17.3	11.4	96.6	2.17	--
	2 (17, 33, 40)				30.0	17.6	110.1	4.01	--
7–20	(18, 25, 28)		Brown, Dry, Very Firm, Thinly Laminated, With Lenses of Fine Sandy Silt and Silty Clay	SILT					
	3				28.5	13.8	101.9	1.88	1.56
	(20, 30, 30)								
	4				28.5	12.0	95.2	2.31	1.37
	(14, 25, 40)								
	5				36.0	9.8	89.9	2.44	1.21

Continued On Drawing No. 37

Note: Used Unconfined Compression Test Data Figure, Divided By 2 For Shear Resistance Figure On Sample No. 1

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	36

SUMMARY SHEET

BORING NO. 17 (Cont.)

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	DESCRIPTION		DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq. Ft.
20–24	21 / 30 / 45		Brown, Dry, Very Firm, Thinly Laminated With Fine Sandy Silt and Clayey Silt Merges	SILT					
24–27	6 8 / 10 / 20		Light Brown to Light Gray Brown, Dry to Slightly Moist, Very Firm	SILTY FINE SAND	51.0	12.4	102.7	3.52	--
27–28			Moist, Firm						
28–30	7	Water	Brown and Light Brown, Saturated, Firm to Very Firm	SILTY CLAY	36.0	24.6	100.5	1.48	--

JOB NAME San Diego Gas & Electric - Imperial Valley Sub...tion

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	37

JOB NAME San Diego Gas & Electric - Imperial Valley Sub...ation

SUMMARY SHEET

BORING NO. 18

ELEVATION 3.22'

DEPTH/FEET	SAMPLE NUMBER	Description	Soil Classification	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS/CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
0–1.5		Light Brown, Dry, Loose	SILTY FINE TO MEDIUM SAND					
1.5–2.5	1	Light Gray Brown, Dry, Loose	SILTY FINE SAND	14.3	8.1	100.4	0.29	--
2.5–7	9, 15, 16; 2; 13, 14, 17	Brown, Dry, Firm, Thinly Laminated With Clayey Silt and Silty Fine to Medium Sand	SILT	15.0	8.9	98.8	1.58	0.67
7–9.5	10, 16, 25	Brown, Slightly Moist, Very Firm, With Thin Lenses Of Clayey Silt	SILTY CLAY					
9.5–18	3	Light Brown, Dry, Very Firm, Thinly Laminated With Silty Fine Sand	FINE SANDY SILT	27.0	6.9	91.1	1.11	0.67
	20, 28, 35; 4			28.5	10.5	102.9	2.88	2.01
	12, 30, 42							
18–20	5	Brown, Dry, Very Firm, With Lenses Of Silty Clay	CLAYEY SILT	36.0	17.1	101.2	3.04	1.94

Continued On Drawing No. 39

PROJECT NO. 80-9-10A

BENTON ENGINEERING, INC.

DRAWING NO. 38

SUMMARY SHEET

BORING NO. 18 (Cont.)

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	DESCRIPTION	SOIL	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
20–23	14 / 20 / 33		Brown, Dry, Very Firm, Interbedded With Silty Clay, Thinly Laminated	CLAYEY SILT					
23–26	6		Brown, Dry, Very Firm, With Lenses Of Fine Sandy Silt	SILTY FINE SAND	52.2	12.4	95.7	2.62	--
26–28.5	17 / 33 / 45		Brown, Dry, Very Firm, Thinly Laminated With Clayey Silt and Fine Sandy Silt	SILT					
28.5–30	7	Water	Brown, Saturated, Very Firm, Interbedded With Silty Clay and Fine Sandy Silt and Lime Cemented Nodules	CLAY	36.0	25.8	99.6	4.10	--

JOB NAME San Diego Gas & Electric – Imperial Valley Subs. ion

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	39

SUMMARY SHEET

BORING NO. 19

ELEVATION 5.89'

DEPTH/FEET	SAMPLE NUMBER	DESCRIPTION	SOIL	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS/CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
0 – 1.4		Gray Brown, Dry, Loose, With Scattered Medium Gravel	SILTY FINE TO MEDIUM SAND					
1.4 – 7.6	1 NR; 11, 19, 22	Brown and Gray Brown, Dry, Firm	SILTY FINE SAND	27.0	--	--	--	--
	2 NR; 15, 18, 18			24.8	--	--	--	--
7.6 – 9.1	8, 14, 20	Red Brown, Slightly Moist, Very Firm, With Thin Lenses Of Silt	CLAY					
9.1 – 10.2	3	Brown, Dry, Very Firm	FINE SANDY SILT	19.5	14.9	105.2	2.73	--
10.2 – 11.3		Brown, Dry, Very Firm, Thinly Bedded	SILT					
11.3 – 12.2	12, 19, 25	Gray Brown, Dry, Firm	FINE SAND					
12.2 – 13.4		Brown, Dry, Very Firm	CLAYEY SILT					
13.4 – 20	4	Red, Brown and Brown, Slightly Moist, Very Firm, With Thin Lenses Of Silty Clay and Clayey Silt, Blocky Structure With Cracks or Fissures, and Loss of Water Circulation Between 19' and 20'	CLAY	27.0	20.2	101.0	3.86	1.50
	16, 18, 25							
	5			21.0	22.2	99.1	2.82	--

Continued On Drawing No. 41

JOB NAME San Diego Gas & Electric - Imperial Valley Station

SUMMARY SHEET

BORING NO. 19 (Cont.)

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	DESCRIPTION	SOIL	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
20–21			Red Brown and Light Brown, Slightly Moist, Very Firm	CLAY					
21–23	27 40 48		Moist						
23–24.5			Light Brown, Moist, Very Firm, Thinly Bedded	SILT					
24.5–28	6		Very Moist, With Scattered Lenses Of Silty Clay and Clayey Silt		60.0	14.0	92.2	2.79	--
	12 13 16								
28–30	7	Water	Brown, Saturated, Very Firm, Interbedded With Silty Clay and Clayey Silt	CLAY	19.5	24.5	100.8	2.39	--

JOB NAME San Diego Gas & Electric – Imperial Valley Su[illegible]tion

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	41

SUMMARY SHEET

BORING NO. 20

ELEVATION 3.06'

DEPTH/FEET	SAMPLE NUMBER	DESCRIPTION	SOIL CLASSIFICATION	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS/CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
0–1		Gray Brown, Dry, Loose	SLIGHTLY SILTY FINE TO MEDIUM SAND					
2	1 (10, 14, 20)	Brown, Dry, Firm to Very Firm, With Lenses Of Silty Clay	CLAYEY SILT	11.3	10.8	103.3	3.11	--
5	2 (8, 11, 11)	Red Brown, Slightly Moist, Firm With Shrinkage Cracks and Thin Lenses Of Silt, Loss of Water Circulation During Drilling	CLAY	20.3	13.2	98.9	1.80	1.14
7–9	(15, 12, 22)	Light Brown, With Scattered Lenses Of Silt Merges	CLAY					
10	3	Brown and Light Gray Brown, Dry, Firm, Thinly Bedded	SILT	28.5	10.4	97.3	0.35	--
11–12	(16, 25, 25)		SILT					
15	4		SILT	26.3	11.5	99.5	2.36	--
16–18	(16, 23, 36)	Brown, Dry, Very Firm, With Lenses Of Clayey Silt	SILTY CLAY					
18–20	5	Brown, Dry, Very Firm, With Lenses Of Fine Sandy Silt	SILTY FINE SAND	30.0	8.5	93.8	2.02	--

Continued On Drawing No. 43

Note: Used Unconfined Compression Test Data Figure, Divided By 2 For Shear Resistance Figure On Sample No. 3.

JOB NAME San Diego Gas & Electric - Imperial Valley Sub..tion

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	42

JOB NAME San Diego Gas & Electric - Imperial Valley Sub...tion

SUMMARY SHEET

BORING NO. 20 (Cont.)

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	Description	Classification	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
20–21	11, 16, 20		Brown, Dry, Very Firm, With Lenses Of Fine Sandy Silt	SILTY FINE SAND					
21–25	6		Brown, Dry to Slightly Moist, Firm, Interbedded With Thin Lenses Of Silt and Clayey Silt and Scattered Calcareous Nodules	FINE SANDY SILT	27.0	21.0	93.2	2.60	--
25–27	5, 7, 13		Brown to Red Brown, Moist, Firm, With Scattered Lime Cemented Nodules	SILTY CLAY					
27–30	7		Brown and Gray Brown, Saturated, Firm, Thinly Bedded With Thin Layers of Silt	CLAYEY SILT	24.0	26.8	97.0	1.48	--
30			Brown, Saturated, Firm	FINE SANDY SILT					

PROJECT NO. 80-9-10A

BENTON ENGINEERING, INC.

DRAWING NO. 43

SUMMARY SHEET

BORING NO. 21

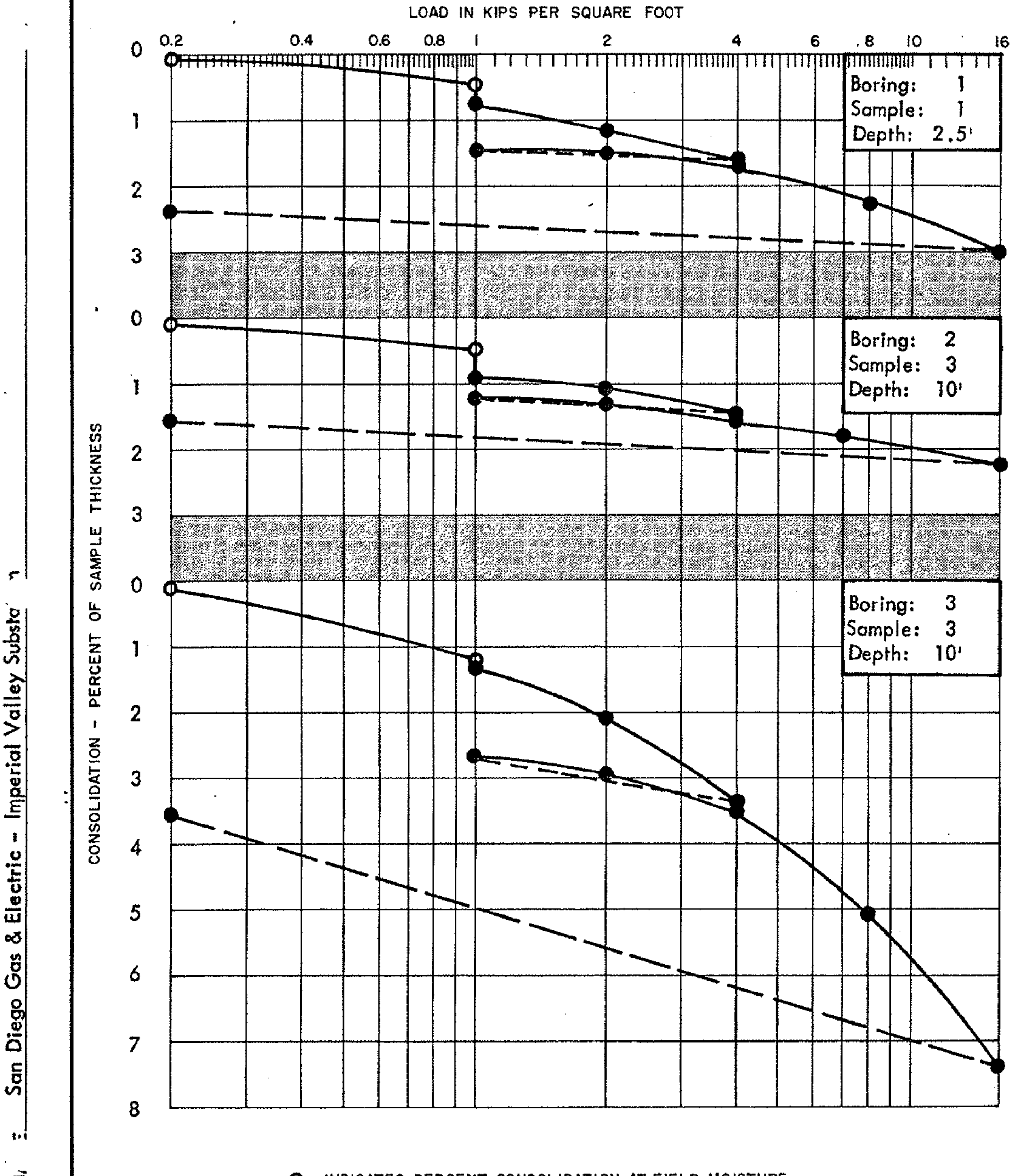
ELEVATION 5.06'

DEPTH/FEET	SAMPLE NUMBER	SOIL CLASSIFICATION SYMBOL	Description	Soil	DRIVE ENERGY FT. KIPS/FT.	FIELD MOISTURE % DRY WT.	DRY DENSITY LBS./CU. FT.	SHEAR RESISTANCE KIPS/SQ. FT.	Sat. Shear Kips/Sq.Ft.
0–1			Light Brown, Dry, Very Loose	SILTY FINE TO MEDIUM SAND					
1–3			Loose to Medium Firm						
3–5.5	1		Gray Brown		1.9	13.3	109.7	0.55	0.50
5.5–8	2		Firm		7.5	9.7	106.1	0.65	0.52
	3				7.5	17.2	107.0	1.17	--
8–10			Gray Brown, Dry, Dense to Very Dense	SLIGHTLY SILTY FINE TO MEDIUM SAND					
10–12	4		Gray Brown, Dry, Very Firm	SILTY FINE TO MEDIUM SAND	11.3	17.7	104.7	1.38	--
12			Extensive Caving Unable to Drill Deeper						

JOB NAME San Diego Gas & Electric – Imperial Valley Substation

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING, INC.	44

CONSOLIDATION CURVES

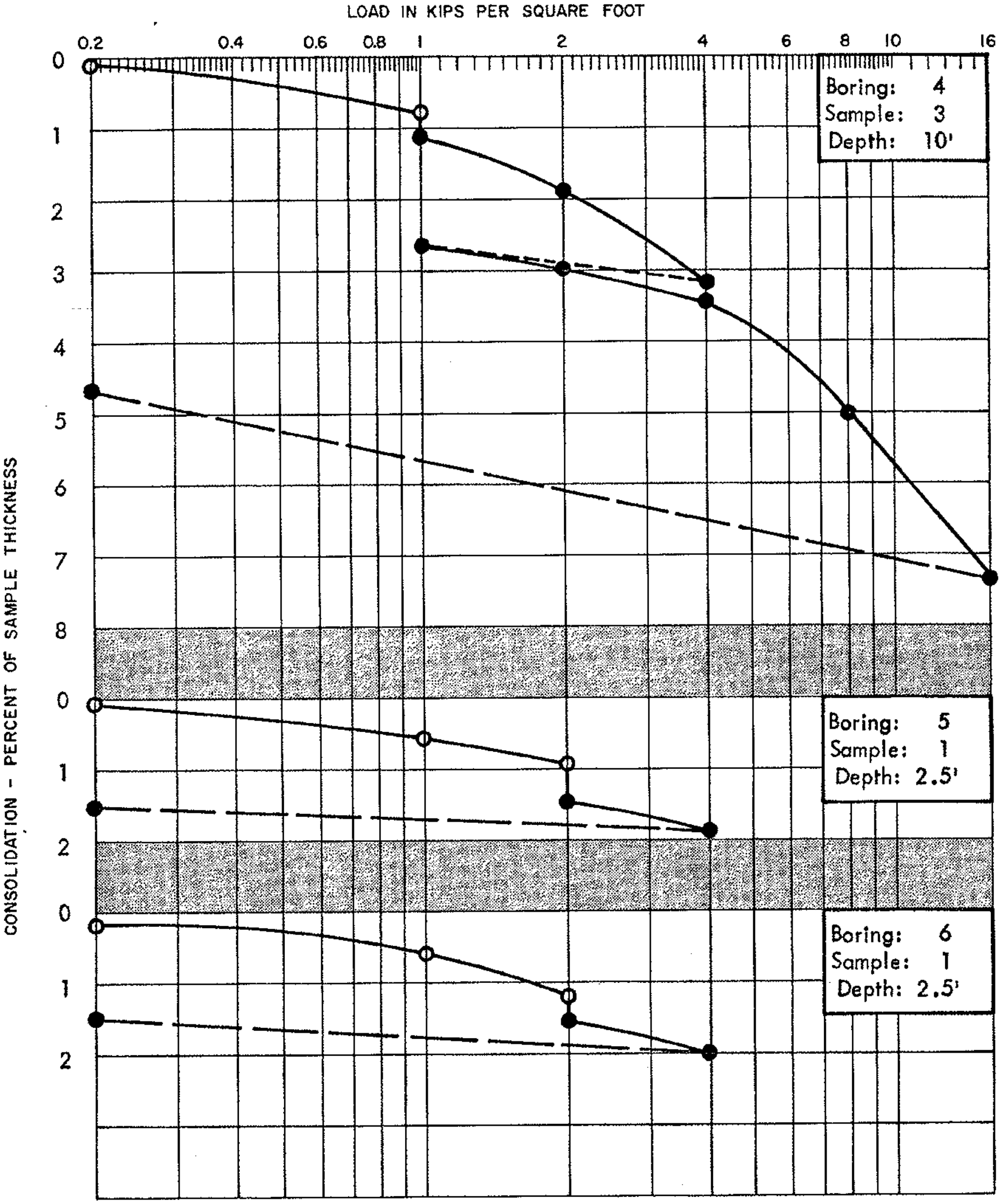


○ INDICATES PERCENT CONSOLIDATION AT FIELD MOISTURE

● INDICATES PERCENT CONSOLIDATION AFTER SATURATION

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING INC.	45

CONSOLIDATION CURVES



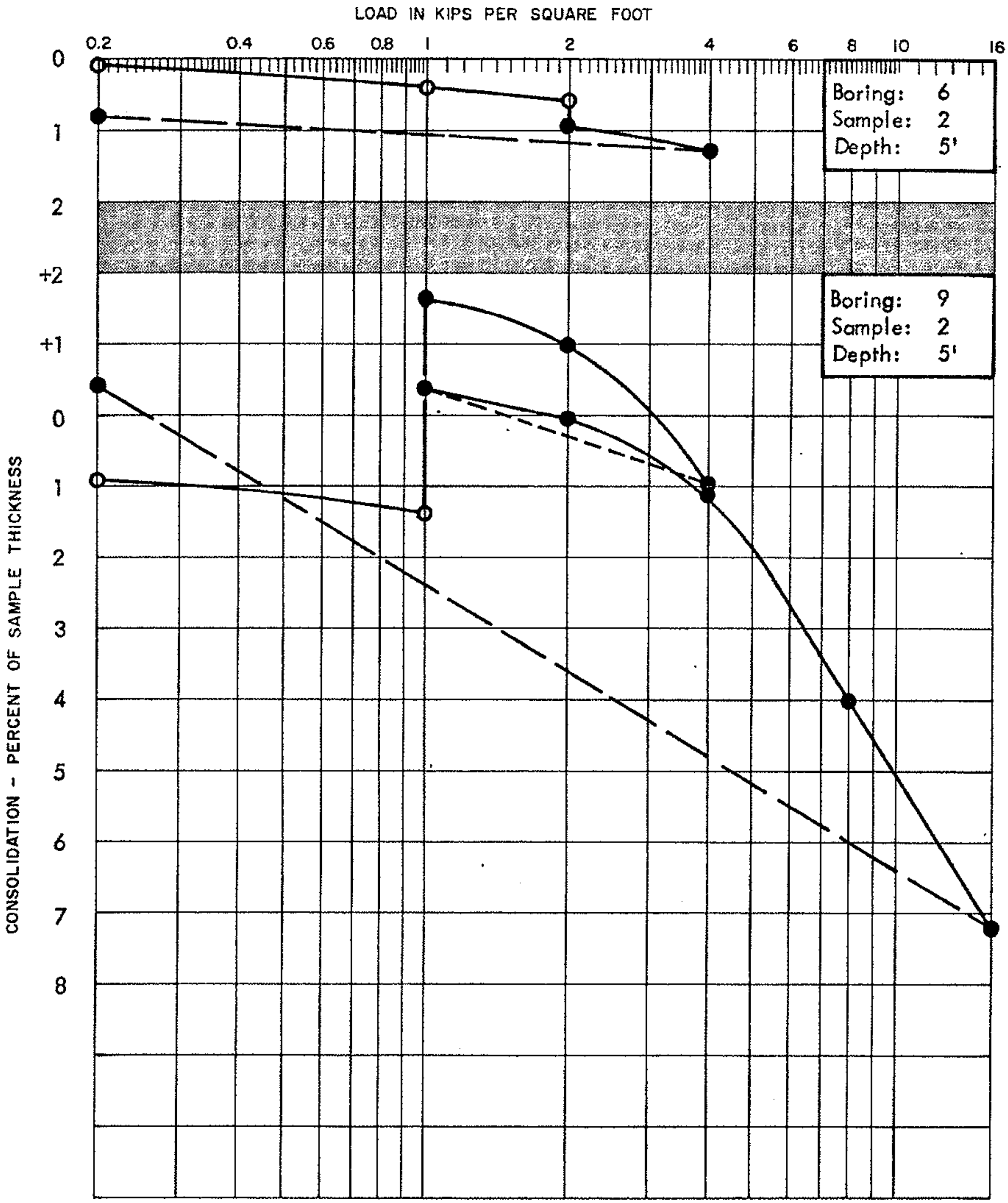
○ INDICATES PERCENT CONSOLIDATION AT FIELD MOISTURE

● INDICATES PERCENT CONSOLIDATION AFTER SATURATION

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING INC.	46

JOB N. E San Diego Gas & Electric - Imperial Valley Substa.

CONSOLIDATION CURVES



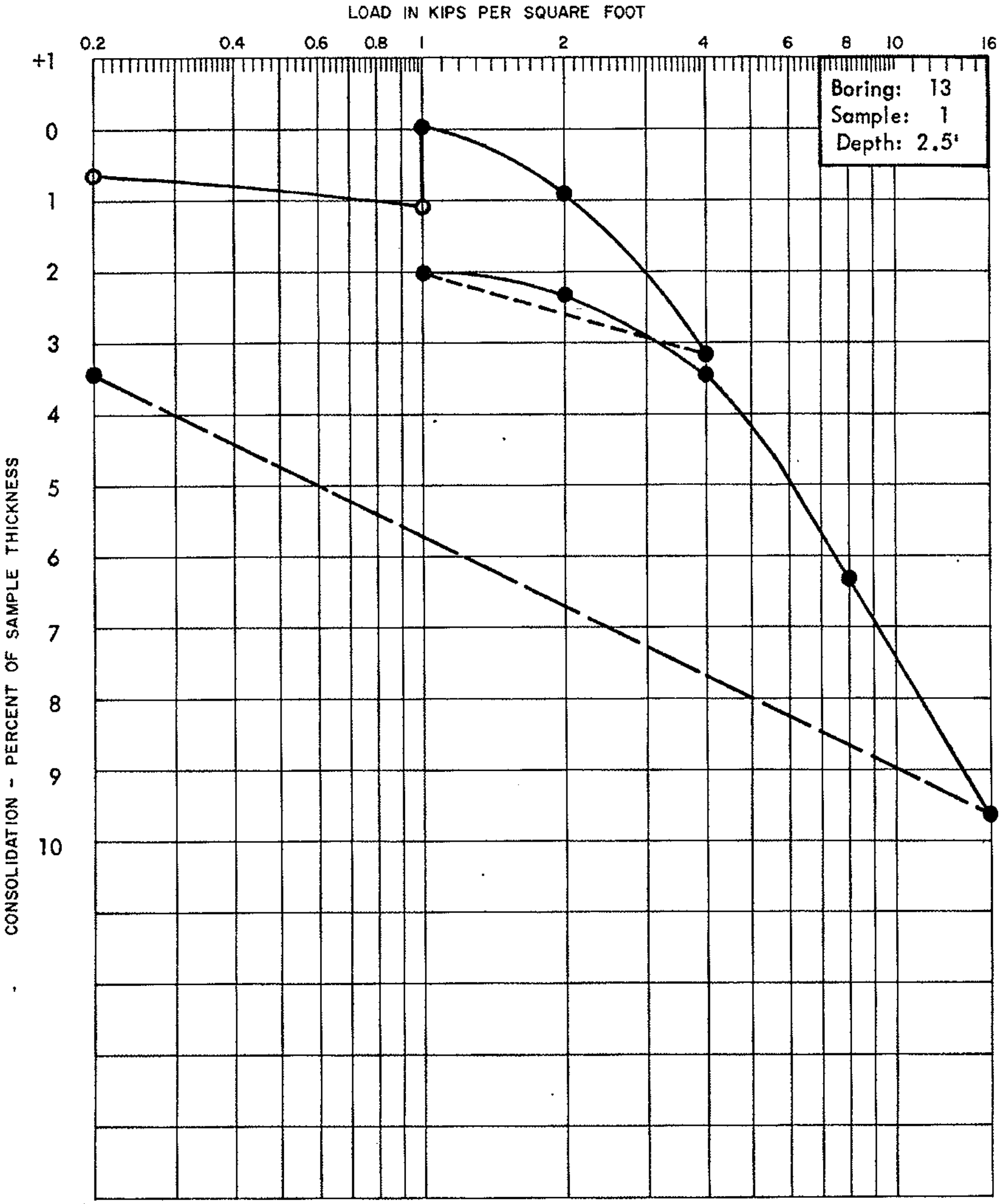
○ INDICATES PERCENT CONSOLIDATION AT FIELD MOISTURE

● INDICATES PERCENT CONSOLIDATION AFTER SATURATION

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING INC.	47

JOB N: San Diego Gas & Electric - Imperial Valley Substat

CONSOLIDATION CURVES



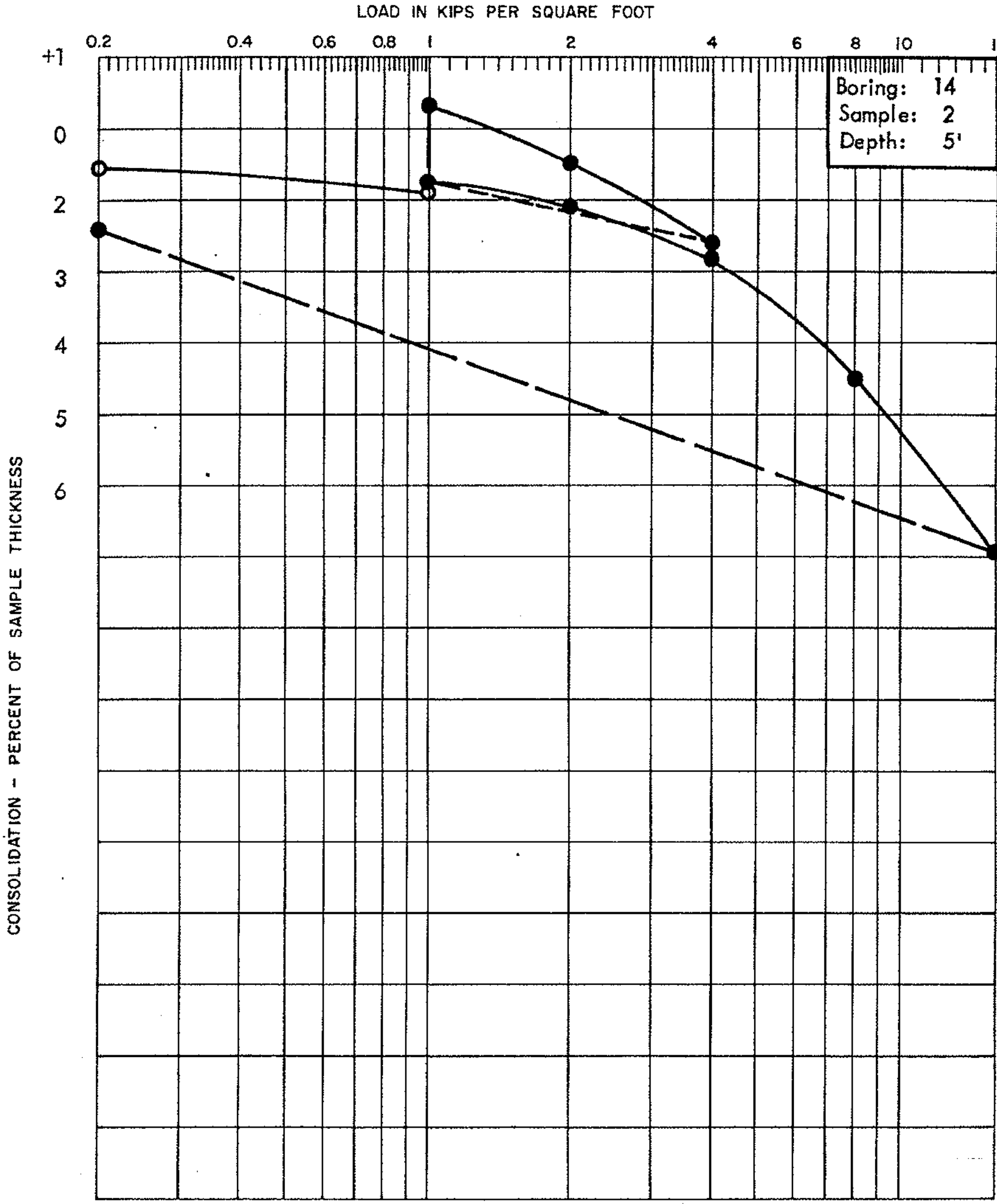
○ INDICATES PERCENT CONSOLIDATION AT FIELD MOISTURE

● INDICATES PERCENT CONSOLIDATION AFTER SATURATION

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING INC.	48

JOB N... E... San Diego Gas & Electric - Imperial Valley Subst... n

CONSOLIDATION CURVES



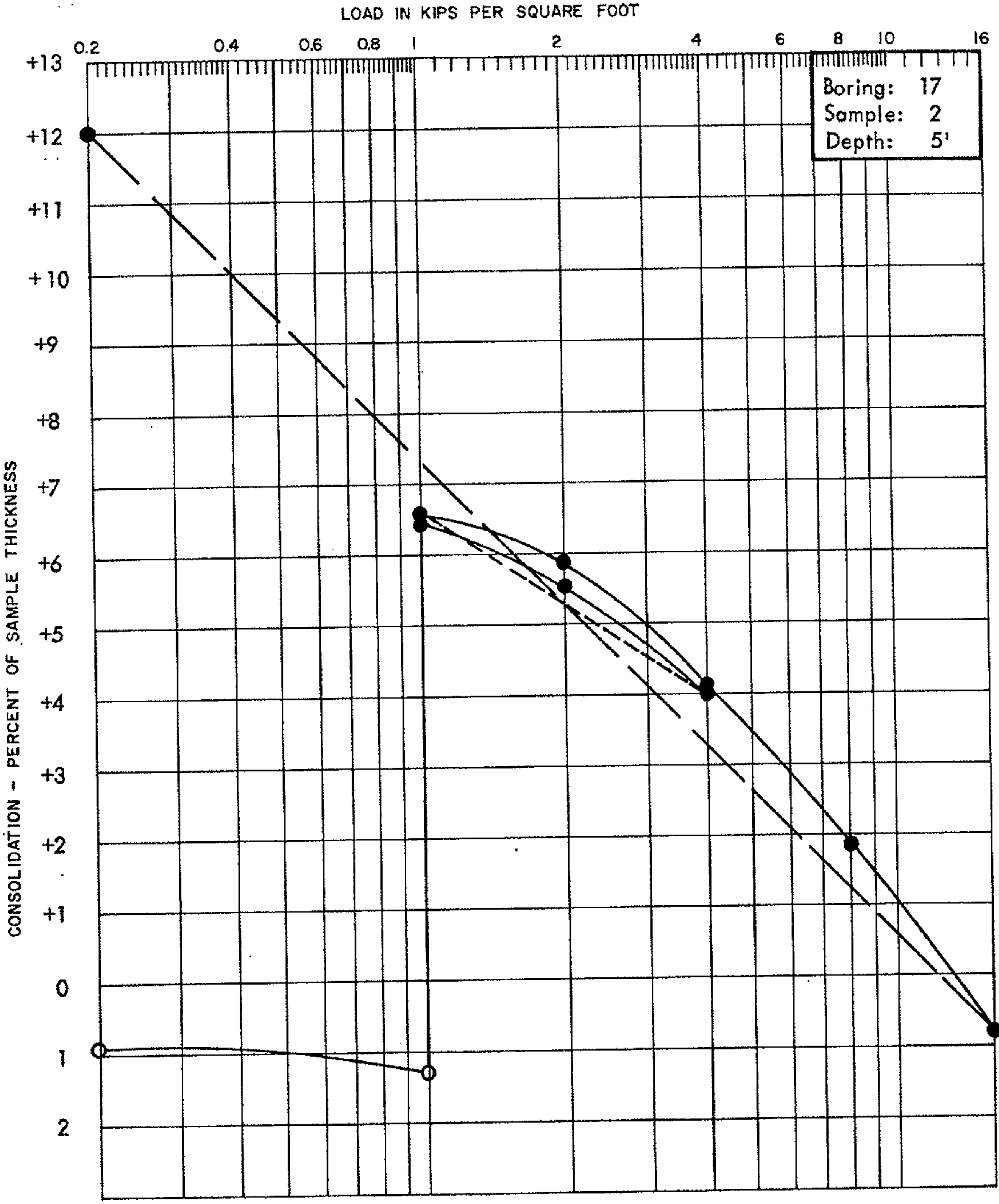
○ INDICATES PERCENT CONSOLIDATION AT FIELD MOISTURE

● INDICATES PERCENT CONSOLIDATION AFTER SATURATION

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING INC.	49

JOB N. E San Diego Gas and Electric - Imperial Valley Subs 'on

CONSOLIDATION CURVES



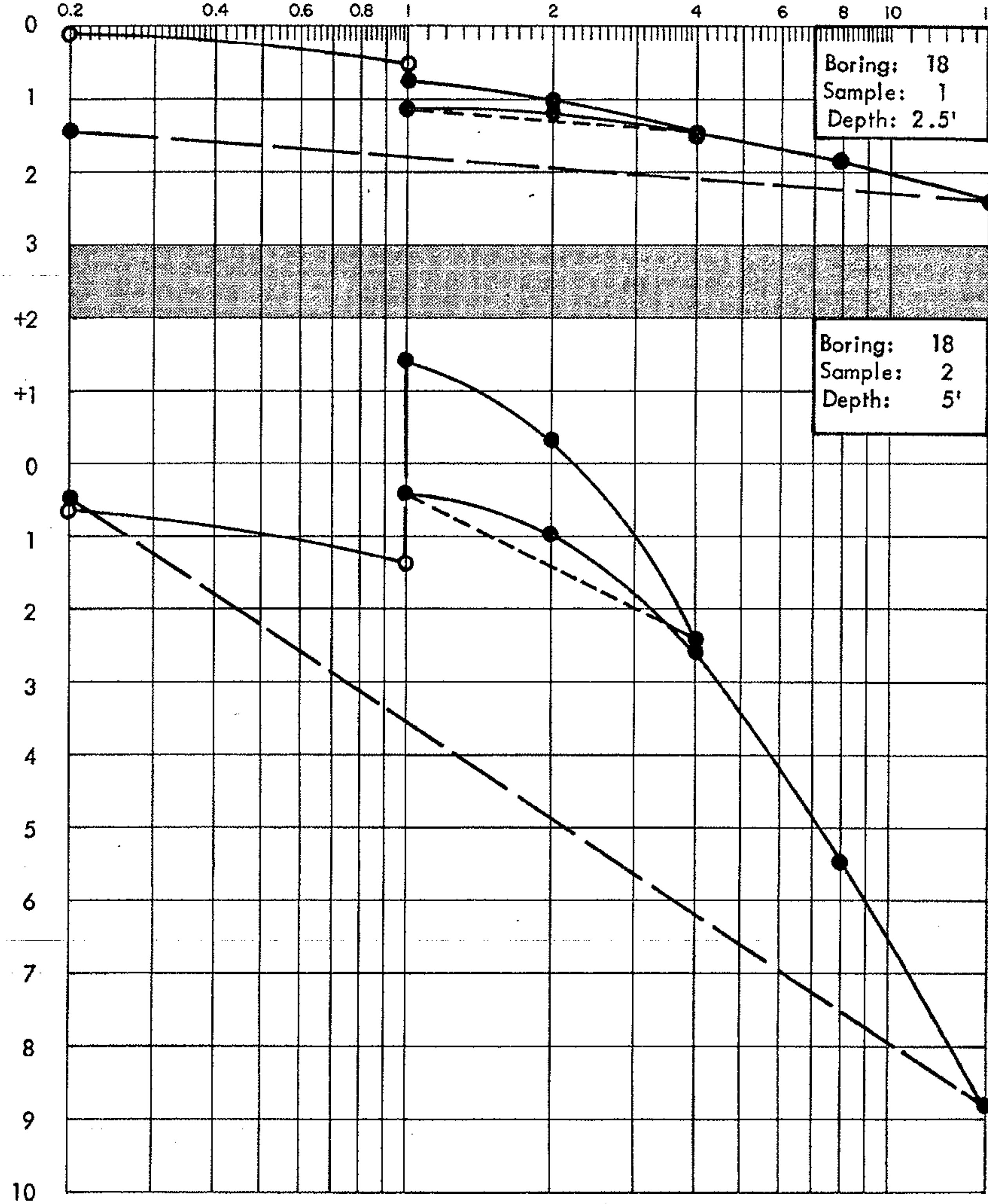
O INDICATES PERCENT CONSOLIDATION AT FIELD MOISTURE

● INDICATES PERCENT CONSOLIDATION AFTER SATURATION

JOB NA. 2 San Diego Gas & Electric - Imperial Valley Subst on

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING INC.	50

CONSOLIDATION CURVES



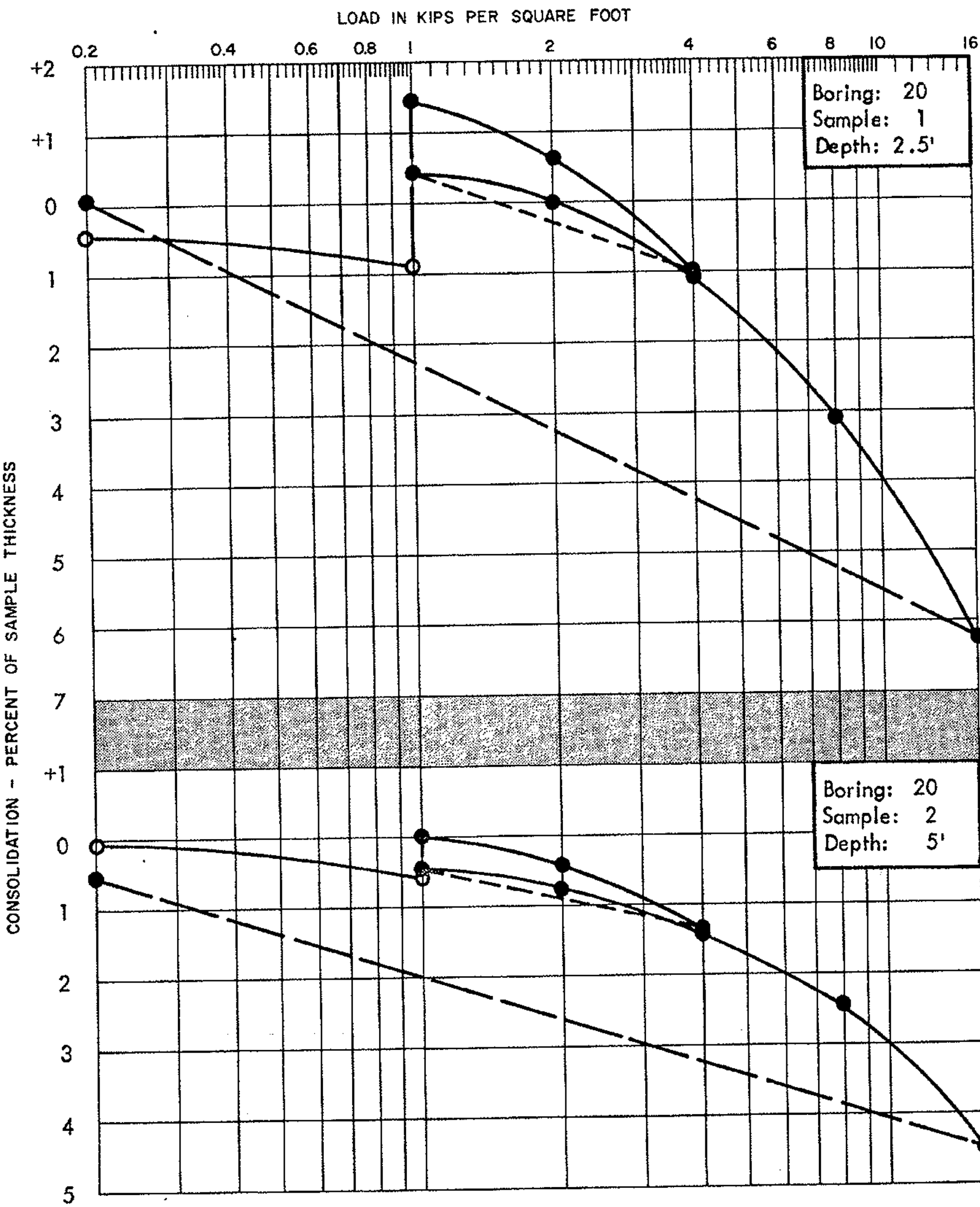
O INDICATES PERCENT CONSOLIDATION AT FIELD MOISTURE

● INDICATES PERCENT CONSOLIDATION AFTER SATURATION

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING INC.	51

JOB No: San Diego Gas & Electric -- Imperial Valley Substa

CONSOLIDATION CURVES



○ INDICATES PERCENT CONSOLIDATION AT FIELD MOISTURE

● INDICATES PERCENT CONSOLIDATION AFTER SATURATION

PROJECT NO.		DRAWING NO.
80-9-10A	BENTON ENGINEERING INC.	52

JOB N. _ San Diego Gas & Electric - Imperial Valley Substa

BENTON ENGINEERING, INC.
APPLIED SOIL MECHANICS — FOUNDATIONS
5540 RUFFIN ROAD
SAN DIEGO, CALIFORNIA 92123

PHILIP HENKING BENTON
PRESIDENT - CIVIL ENGINEER

TELEPHONE (714) 565-1955

APPENDIX AA

STANDARD SPECIFICATIONS FOR PLACEMENT OF COMPACTED FILLED GROUND

1. General Description. The objective is to attain uniformity and adequate internal strength in filled ground by proven engineering procedures and tests so that the proposed structures may be safely supported. The procedures include the clearing and grubbing, removal of existing structures, preparation of land to be filled, filling of the land, the spreading, and compaction of the filled areas to conform with the lines, grades, and slopes as shown on the accepted plans.

   The owner shall employ a qualified soils engineer to inspect and test the filled ground as placed to verify the uniformity of compaction of filled ground to the specified 90 percent of maximum dry density. The soils engineer shall advise the owner and grading contractor immediately if any unsatisfactory conditions are observed to exist and shall have the authority to reject the compacted filled ground until such time that corrective measures are taken necessary to comply with the specifications. It shall be the sole responsibility of the grading contractor to achieve the specified degree of compaction.

2. Clearing, Grubbing, and Preparing Areas to be Filled.

   (a) All brush, vegetation and any rubbish shall be removed, piled, and burned or otherwise disposed of so as to leave the areas to be filled free of vegetation and debris. Any soft, swampy or otherwise unsuitable areas shall be corrected by draining or removal, or both.

   (b) The natural ground which is determined to be satisfactory for the support of the filled ground shall then be plowed or scarified to a depth of at least six inches (6"), and until the surface is free from ruts, hummocks, or other uneven features which would tend to prevent uniform compaction by the equipment to be used.

   (c) Where fills are made on hillsides or exposed slope areas, greater than 10 percent, horizontal benches shall be cut into firm undisturbed natural ground in order to provide both lateral and vertical stability. This is to provide a horizontal base so that each layer is placed and compacted on a horizontal plane. The initial bench at the toe of the fill shall be at least 10 feet in width on firm undisturbed natural ground at the elevation of the toe stake placed at the natural angle of repose or design slope. The soils engineer shall determine the width and frequency of all succeeding benches which will vary with the soil conditions and the steepness of slope.

(d) After the natural ground has been prepared, it shall then be brought to the proper moisture content and compacted to not less than ninety percent of maximum density in accordance with A.S.T.M. D-1557-70 method that uses 25 blows of a 10 pound hammer falling from 18 inches on each of 5 layers in a 4" diameter cylindrical mold of a 1/30th cubic foot volume.

3. Materials and Special Requirements. The fill soils shall consist of select materials so graded that at least 40 percent of the material passes a No. 4 sieve. This may be obtained from the excavation of banks, borrow pits of any other approved sources and by mixing soils from one or more sources. The material used shall be free from vegetable matter, and other deleterious substances, and shall not contain rocks or lumps of greater than 6 inches in diameter. If excessive vegetation, rocks, or soils with inadequate strength or other unacceptable physical characteristics are encountered, these shall be disposed of in waste areas as shown on the plans or as directed by the soils engineer. If during grading operations, soils not encountered and tested in the preliminary investigation are found, tests on these soils shall be performed to determine their physical characteristics. Any special treatment recommended in the preliminary or subsequent soil reports not covered herein shall become an addendum to these specifications.

The testing and specifications for the compaction of subgrade, subbase, and base materials for roads, streets, highways, or other public property or rights-of-way shall be in accordance with those of the governmental agency having jurisdiction.

4. Placing, Spreading, and Compacting Fill Materials.

(a) The suitable fill material shall be placed in layers which, when compacted shall not exceed six inches (6"). Each layer shall be spread evenly and shall be throughly mixed during the spreading to insure uniformity of material and moisture in each layer.

(b) When the moisture content of the fill material is below that specified by the soils engineer, water shall be added until the moisture content is near optimum as specified by the soils engineer to assure thorough bonding during the compacting process.

(c) When the moisture content of the fill material is above that specified by the soils engineer, the fill material shall be aerated by blading and scarifying or other satisfactory methods until the moisture content is near optimum as specified by the soils engineer.

(d) After each layer has been placed, mixed and spread evenly, it shall be thoroughly compacted to not less than ninety percent of maximum density in accordance with A.S.T.M. D-1557-70 modified as described in 2 (d) above. Compaction shall be accomplished with sheepsfoot rollers, multiple-wheel pneumatic-tired rollers, or other approved types of compaction equipment, such as vibratory equipment that is specially designed for certain soil types. Rollers shall be of such design that they will be able to compact the fill material to the specified density. Rolling shall be accomplished while the fill material is at the specified moisture content. Rolling of each layer shall be continuous over its entire area and the roller shall make sufficient trips to insure that the desired density has been obtained. The entire areas to be filled shall be compacted.

(e) Fill slopes shall be compacted by means of sheepsfoot rollers or other suitable equipment. Compacting operations shall be continued until the slopes are stable but not too dense for planting and until there is no appreciable amount of loose soil on the slopes. Compacting of the slopes shall be accomplished by backrolling the slopes in increments of 3 to 5 feet in elevation gain or by other methods producing satisfactory results.

(f) Field density tests shall be taken by the soils engineer for approximately each foot in elevation gain after compaction, but not to exceed two feet in vertical height between tests. Field density tests may be taken at intervals of 6 inches in elevation gain if required by the soils engineer. The location of the tests in plan shall be so spaced to give the best possible coverage and shall be taken no farther apart than 100 feet. Tests shall be taken on corner and terrace lots for each two feet in elevation gain. The soils engineer may take additional tests as considered necessary to check on the uniformity of compaction. Where sheepsfoot rollers are used, the tests shall be taken in the compacted material below the disturbed surface. No additional layers of fill shall be spread until the field density tests indicate that the specified density has been obtained.

(g) The fill operation shall be continued in six inch (6") compacted layers, as specified above, until the fill has been brought to the finished slopes and grades as shown on the accepted plans.

5. Inspection. Sufficient inspection by the soils engineer shall be maintained during the filling and compacting operations so that he can certify that the fill was constructed in accordance with the accepted specifications.

6. Seasonal Limits. No fill material shall be placed, spread, or rolled if weather conditions increase the moisture content above permissible limits. When the work is interrupted by rain, fill operations shall not be resumed until field tests by the soils engineer indicate that the moisture content and density of the fill are as previously specified.

7. All recommendations presented in the "Conclusions" section of the attached report are a part of these specifications.

BENTON ENGINEERING, INC.
APPLIED SOIL MECHANICS — FOUNDATIONS
5540 RUFFIN ROAD
SAN DIEGO, CALIFORNIA 92123

PHILIP HENKING BENTON
PRESIDENT - CIVIL ENGINEER

TELEPHONE (714) 565-1955

APPENDIX A
Unified Soil Classification Chart*

SOIL DESCRIPTION		GROUP SYMBOL	TYPICAL NAMES
I. COARSE GRAINED, More than half of material is larger than No. 200 sieve size.**			
GRAVELS More than half of coarse fraction is larger than No. 4 sieve size but smaller than 3 inches	CLEAN GRAVELS	GW	Well graded gravels, gravel-sand mixtures, little or no fines.
		GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.
	GRAVELS WITH FINES (Appreciable amount of fines)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures.
		GC	Clayey gravels, poorly graded gravel-sand-clay mixtures.
SANDS More than half of coarse fraction is smaller than No. 4 sieve size	CLEAN SANDS	SW	Well graded sand, gravelly sands, little or no fines.
		SP	Poorly graded sands, gravelly sands, little or no fines.
	SANDS WITH FINES (Appreciable amount of fines)	SM	Silty sands, poorly graded sand-silt mixtures.
		SC	Clayey sands, poorly graded sand-clay mixtures.
II. FINE GRAINED, More than half of material is smaller than No. 200 sieve size.**	SILTS AND CLAYS	ML	Inorganic silts and very fine sands, rock flour, sandy silt or clayey-silt-sand mixtures with slight plasticity.
	Liquid Limit Less than 50	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
	Liquid Limit Greater than 50	CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity
III. HIGHLY ORGANIC SOILS		PT	Peat and other highly organic soils.

* Adopted by the Corps of Engineers and Bureau of Reclamation in January, 1952.
** All sieve sizes on this chart are U. S. Standard.

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APPENDIX B

Sampling

The undisturbed soil samples are obtained by forcing a special sampling tube into the undisturbed soils at the bottom of the boring, at frequent intervals below the ground surface. The sampling tube consists of a steel barrel 3.0 inches outside diameter, with a special cutting tip on one end and a double ball valve on the other, and with a lining of twelve thin brass rings, each one inch long by 2.42 inches inside diameter. The sampler, connected to a twelve inch long waste barrel, is either pushed or driven approximately 18 inches into the soil and a six inch section of the center portion of the sample is taken for laboratory tests, the soil being still confined in the brass rings, after extraction from the sampler tube. The samples are taken to the laboratory in close fitting waterproof containers in order to retain the field moisture until completion of the tests. The driving energy is calculated as the average energy in foot-kips required to force the sampling tube through one foot of soil at the depth at which the sample is obtained.

Shear Tests

The shear tests are run using a direct shear machine of the strain control type in which the rate of deformation is approximately 0.05 inch per minute. The machine is so designed that the tests are made without removing the samples from the brass liner rings in which they are secured. Each sample is sheared under a normal load equivalent to the weight of the soil above the point of sampling. In some instances, samples are sheared under various normal loads in order to obtain the internal angle of friction and cohesion. Where considered necessary, samples are saturated and drained before shearing in order to simulate extreme field moisture conditions.

Consolidation Tests

The apparatus used for the consolidation tests is designed to receive one of the one inch high rings of soil as it comes from the field. Loads are applied in several increments to the upper surface of the test specimen and the resulting deformations are recorded at selected time intervals for each increment. Generally, each increment of load is maintained on the sample until the rate of deformation is equal to or less than 1/10000 inch per hour. Porous stones are placed in contact with the top and bottom of each specimen to permit the ready addition or release of water.

Expansion Tests

One inch high samples confined in the brass rings are permitted to air dry at 105° F for at least 48 hours prior to placing into the expansion apparatus. A unit load of 500 pounds per square foot is then applied to the upper porous stone in contact with the top of each sample. Water is permitted to contact both the top and bottom of each sample through porous stones. Continuous observations are made until downward movement stops. The dial reading is recorded and expansion is recorded until the rate of upward movement is less than 1/10000 inch per hour.

APPENDIX C

Chemical Analysis Tests
by
Environmental Engineering Laboratory

ENVIRONMENTAL
ENGINEERING
LABORATORY

3538 HANCOCK STREET
SAN DIEGO, CALIF. 92110
P. O. BOX 81789
SAN DIEGO, CALIF. 92138
PHONE: 298-6131

November 10, 1980

Benton Engineering
5540 Ruffin Rd.
San Diego, Ca 92123

LABORATORY REPORT

Soil samples from Imperial Valley 80-9-10-A received October 20, 1980

Results are mg/L from 1:1 extract

Hole #	Bag #	Depth	Chloride	Sulfate
1	4	14' to 15'	39	148
4	Spt 5	17.5'	34	181
6	Spt 6	22.5'	37	280
8	Spt 6	22.5'	39	239
11	4	14' to 15'	576	651
12	6	24' to 25'	915	836
14	4	14' to 15'	265	235
16	Spt 7	27.5'	688	634
17	5	19' to 20'	311	416
19	5	19' to 20'	384	466

Submitted by,

Robert L. Chambers

Robert L. Chambers
Director

E RONMENTAL ENGINEERING LABORATORY

3538 HANCOCK STREET, SAN DIEGO, CALIF. 92110 • PHONE: 298-613,
P. O. BOX 81789, SAN DIEGO, CALIF. 92138

Sample Source: Imp. Val. 80-9-10-A
Hole # 2 Bag # 1, Depth: 1.5' to 2..

Benton Engineering
5540 Ruffin Rd.
San Diego, Ca 92123

Date November 10, 1980
Date Collected
Date Received October 20, 1980

Conductivity 130 micromhos/cm @ 25°C
pH 7.70

Principal Constituents		mg/l	me/l			mg/l			mg/l
Cations:									
Calcium	Ca			Aluminum	Al		Barium	Ba	
Magnesium	Mg			Zinc	Zn		Cadmium	Cd	
Sodium	Na			Hexavalent Chromium	Cr		Silver	Ag	
Potassium	K			Total Chromium	Cr		Mercury	Hg	
Ammonia	NH_4	5.7		Arsenic	As		Gold	Au	
% Sodium				Lead	Pb				
				Copper	Cu				
Anions:				Selenium	Se				
Hydroxide	OH	0		Nickel	Ni				
Carbonate	CO_3	0							
Bicarbonate	HCO_3	84		Cyanide	CN				
Sulfate	SO_4	58		Phenols					
Chloride	Cl	22		M B A S					
Nitrate	NO_3	2.0		Grease & Oil					
Fluoride	F			Sulfides		< 2			
				Volatile Acids					
Boron	B			Suspended Solids					
Silica	SiO_2			Volatile Suspended Solids					
Iron	Fe			Dissolved Solids					
Manganese	Mn			Volatile Dissolved Solids					
Total Phosphate	PO_4			Settleable Solids					
Ortho Phosphate	PO_4			BOD, 5 day 20°C					
Nitrite	N	0.008		Oxygen Consumed					
Nitrate	N	0.46		Coliform, MPN/100 ml					
Ammonia	N	4.4		Plate Count/ml					
Total Organic Nitrogen	N			Plankton Count/ml					
Total Kjeldahl Nitrogen	N			Radioactivity Picocuries/ml					
Total Alkalinity	$CaCO_3$	69							
Total Hardness	$CaCO_3$								
Dissolved Solids									
Turbidity, Units									

Remarks Results are from 1:1 extract except Ammonia and Sulfide

Approved Water Laboratory, California State Department of Public Health

Reported By Robert L. Chamberlain

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Benton Engineering
5540 Ruffin Rd.
San Diego, Ca 92123

Date November 10, 1980
Date Collected
Date Received October 20, 1980

Sample Source: Imperial Valley 80-9-10-A
Hole # 3 Bag # 2, Depth: 4' to 5'

Conductivity 820 micromhos/cm @ 25°C
pH 7.94

Principal Constituents										
Cations:		mg/l	me/l			mg/l			mg/l
Calcium	Ca			Aluminum	Al		Barium	Ba	
Magnesium	Mg			Zinc	Zn		Cadmium	Cd	
Sodium	Na			Hexavalent Chromium	Cr		Silver	Ag	
Potassium	K			Total Chromium	Cr		Mercury	Hg	
Ammonia	NH_4	5.5		Arsenic	As		Gold	Au	
% Sodium				Lead	Pb				
				Copper	Cu				
Anions:				Selenium	Se				
Hydroxide	OH	0		Nickel	Ni				
Carbonate	CO_3	0							
Bicarbonate	HCO_3	128		Cyanide	CN				
Sulfate	SO_4	391		Phenols					
Chloride	Cl	81		M B A S					
Nitrate	NO_3	0.80		Grease & Oil					
Fluoride	F			Sulfides		< 2			
				Volatile Acids					
Boron	B			Suspended Solids					
Silica	SiO_2			Volatile Suspended Solids					
Iron	Fe			Dissolved Solids					
Manganese	Mn			Volatile Dissolved Solids					
Total Phosphate	PO_4			Settleable Solids					
Ortho Phosphate	PO_4			BOD, 5 day 20°C					
Nitrite	N	0.051		Oxygen Consumed					
Nitrate	N	0.18		Coliform, MPN/100 ml					
Ammonia	N	4.3		Plate Count/ml					
Total Organic Nitrogen	N			Plankton Count/ml					
Total Kjeldahl Nitrogen	N			Radioactivity Picocuries/ml					
Total Alkalinity	$CaCO_3$	105							
Total Hardness	$CaCO_3$								
Dissolved Solids									
Turbidity, Units									

Remarks Results are from 1:1 extract except Ammonia and Sulfide

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Reported By Robert R. Chambers

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P. O. BOX 81789, SAN DIEGO, CALIF. 92138

Sample Source: Imp. Val. 80-9-10-A
Hole 5 Bag Spt 1, Depth: 4'

Benton Engineering
5540 Ruffin Rd.
San Diego, Ca 92123

Date November 10, 1980
Date Collected
Date Received October 20, 1980

Conductivity 800 micromhos/cm @ 25°C
pH 7.89

Principal Constituents		mg/l	me/l
Cations:			
Calcium	Ca		
Magnesium	Mg		
Sodium	Na		
Potassium	K		
Ammonia	NH_4	6.8	
% Sodium			
Anions:			
Hydroxide	OH	0	
Carbonate	CO_3	0	
Bicarbonate	HCO_3	116	
Sulfate	SO_4	284	
Chloride	Cl	146	
Nitrate	NO_3	0.97	
Fluoride	F		
Boron	B		
Silica	SiO_2		
Iron	Fe		
Manganese	Mn		
Total Phosphate	PO_4		
Ortho Phosphate	PO_4		
Nitrite	N	0.038	
Nitrate	N	0.22	
Ammonia	N	5.2	
Total Organic Nitrogen	N		
Total Kjeldahl Nitrogen	N		
Total Alkalinity	$CaCO_3$	95	
Total Hardness	$CaCO_3$		
Dissolved Solids			
Turbidity, Units			

		mg/l
Aluminum	Al	
Zinc	Zn	
Hexavalent Chromium	Cr	
Total Chromium	Cr	
Arsenic	As	
Lead	Pb	
Copper	Cu	
Selenium	Se	
Nickel	Ni	
Cyanide	CN	
Phenols		
M B A S		
Grease & Oil		
Sulfides		< 2
Volatile Acids		
Suspended Solids		
Volatile Suspended Solids		
Dissolved Solids		
Volatile Dissolved Solids		
Settleable Solids		
BOD, 5 day 20°C		
Oxygen Consumed		
Coliform, MPN/100 ml		
Plate Count/ml		
Plankton Count/ml		
Radioactivity Picocuries/ml		

		mg/l
Barium	Ba	
Cadmium	Cd	
Silver	Ag	
Mercury	Hg	
Gold	Au	

Remarks Results are from 1:1 extract except Ammonia and Sulfide

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Reported By Robert L. Chambers

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P. O. BOX 81789, SAN DIEGO, CALIF. 92138

Benton Engineering
5540 Ruffin Rd.
San Diego, Ca 92123

Date November 10, 1980
Date Collected
Date Received October 20, 1980

Sample Source: Imp Valley 80-9-10-A
Hole 7 Bag Spt 3, Depth: 9'

Conductivity 810 micromhos/cm @ 25°C
pH 7.84

Principal Constituents									
Cations:		mg/l	me/l			mg/l			mg/l
Calcium	Ca			Aluminum	Al		Barium	Ba	
Magnesium	Mg			Zinc	Zn		Cadmium	Cd	
Sodium	Na			Hexavalent Chromium	Cr		Silver	Ag	
Potassium	K			Total Chromium	Cr		Mercury	Hg	
Ammonia	NH_4	8.0		Arsenic	As		Gold	Au	
% Sodium				Lead	Pb				
				Copper	Cu				
Anions:				Selenium	Se				
Hydroxide	OH	0		Nickel	Ni				
Carbonate	CO_3	0							
Bicarbonate	HCO_3	98		Cyanide	CN				
Sulfate	SO_4	280		Phenols					
Chloride	Cl	169		M B A S					
Nitrate	NO_3	0.71		Grease & Oil					
Fluoride	F			Sulfides		< 2			
				Volatile Acids					
Boron	B			Suspended Solids					
Silica	SiO_2			Volatile Suspended Solids					
Iron	Fe			Dissolved Solids					
Manganese	Mn			Volatile Dissolved Solids					
Total Phosphate	PO_4			Settleable Solids					
Ortho Phosphate	PO_4			BOD, 5 day 20°C					
Nitrite	N	0.009		Oxygen Consumed					
Nitrate	N	0.16		Coliform, MPN/100 ml					
Ammonia	N	6.2		Plate Count/ml					
Total Organic Nitrogen	N			Plankton Count/ml					
Total Kjeldahl Nitrogen	N			Radioactivity Picocuries/ml					
Total Alkalinity	$CaCO_3$	80							
Total Hardness	$CaCO_3$								
Dissolved Solids									
Turbidity, Units									

Remarks Results are from 1:1 extract except Ammonia and Sulfide

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P. O. BOX 81789, SAN DIEGO, CALIF. 92138

Sample Source: Imp. Val. 80-9-10-A
Hole 9 Bag 1, Depth: 1.5' to 2.5'

Benton Engineering
5540 Ruffin Rd.
San Diego, Ca 92123

Date: November 10, 1980
Date Collected:
Date Received: October 20, 1980

Conductivity: 750 micromhos/cm @ 25°C
pH: 7.87

Principal Constituents		mg/l	me/l			mg/l			mg/l
Cations:									
Calcium	Ca			Aluminum	Al		Barium	Ba	
Magnesium	Mg			Zinc	Zn		Cadmium	Cd	
Sodium	Na			Hexavalent Chromium	Cr		Silver	Ag	
Potassium	K			Total Chromium	Cr		Mercury	Hg	
Ammonia	NH_4	6.3		Arsenic	As		Gold	Au	
% Sodium				Lead	Pb				
				Copper	Cu				
Anions:				Selenium	Se				
Hydroxide	OH	0		Nickel	Ni				
Carbonate	CO_3	0							
Bicarbonate	HCO_3	122		Cyanide	CN				
Sulfate	SO_4	231		Phenols					
Chloride	Cl	237		M B A S					
Nitrate	NO_3	0.71		Grease & Oil					
Fluoride	F			Sulfides		< 2			
				Volatile Acids					
Boron	B			Suspended Solids					
Silica	SiO_2			Volatile Suspended Solids					
Iron	Fe			Dissolved Solids					
Manganese	Mn			Volatile Dissolved Solids					
Total Phosphate	PO_4			Settleable Solids					
Ortho Phosphate	PO_4			BOD, 5 day 20°C					
Nitrite	N	0.020		Oxygen Consumed					
Nitrate	N	0.16		Coliform, MPN/100 ml					
Ammonia	N	4.9		Plate Count/ml					
Total Organic Nitrogen	N			Plankton Count/ml					
Total Kjeldahl Nitrogen	N			Radioactivity Picocuries/ml					
Total Alkalinity	$CaCO_3$	100							
Total Hardness	$CaCO_3$								
Dissolved Solids									
Turbidity, Units									

Remarks

Reported By: Robert L. Chambers

Approved Water Laboratory, California State Department of Public Health

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Benton Engineering
5540 Ruffin Rd.
San Diego, Ca 92123

Date: November 10, 1980
Date Collected:
Date Received: October 20, 1980

Sample Source: Imp. Val. 80-9-10-A
Bag 2 Hole 10, Depth: 4' to 5'

Conductivity: 900 micromhos/cm @ 25°C
pH: 7.76

Principal Constituents		mg/l	me/l			mg/l			mg/l
Cations:									
Calcium	Ca			Aluminum	Al		Barium	Ba	
Magnesium	Mg			Zinc	Zn		Cadmium	Cd	
Sodium	Na			Hexavalent Chromium	Cr		Silver	Ag	
Potassium	K			Total Chromium	Cr		Mercury	Hg	
Ammonia	NH_4	4.6		Arsenic	As		Gold	Au	
% Sodium				Lead	Pb				
				Copper	Cu				
Anions:				Selenium	Se				
Hydroxide	OH	0		Nickel	Ni				
Carbonate	CO_3	0							
Bicarbonate	HCO_3	104		Cyanide	CN				
Sulfate	SO_4	412		Phenols					
Chloride	Cl	136		M B A S					
Nitrate	NO_3	0.75		Grease & Oil					
Fluoride	F			Sulfides		< 2			
				Volatile Acids					
Boron	B			Suspended Solids					
Silica	SiO_2			Volatile Suspended Solids					
Iron	Fe			Dissolved Solids					
Manganese	Mn			Volatile Dissolved Solids					
Total Phosphate	PO_4			Settleable Solids					
Ortho Phosphate	PO_4			BOD, 5 day 20°C					
Nitrite	N	0.063		Oxygen Consumed					
Nitrate	N	0.17		Coliform, MPN/100 ml					
Ammonia	N	3.6		Plate Count/ml					
Total Organic Nitrogen	N			Plankton Count/ml					
Total Kjeldahl Nitrogen	N			Radioactivity Picocuries/ml					
Total Alkalinity	$CaCO_3$	85							
Total Hardness	$CaCO_3$								
Dissolved Solids									
Turbidity, Units									

Remarks: Results are from 1:1 extract except Ammonia and Sulfide

Approved Water Laboratory, California State Department of Public Health

Reported By: Robert L. Chambers

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Benton Engineering
5540 Ruffin Rd.
San Diego, Ca 92123

Date: November 10, 1980
Date Collected:
Date Received: October 20, 1980

Sample Source: Imp Val. 80-9-10-A
Hole 13 Bag Spt 2, Depth: 6.5'

Conductivity: 1250 micromhos/cm @ 25°C
pH: 8.03

Principal Constituents		mg/l	me/l			mg/l			mg/l
Cations:									
Calcium	Ca			Aluminum	Al		Barium	Ba	
Magnesium	Mg			Zinc	Zn		Cadmium	Cd	
Sodium	Na			Hexavalent Chromium	Cr		Silver	Ag	
Potassium	K			Total Chromium	Cr		Mercury	Hg	
Ammonia	NH_4	13		Arsenic	As		Gold	Au	
% Sodium				Lead	Pb				
				Copper	Cu				
Anions:				Selenium	Se				
Hydroxide	OH	0		Nickel	Ni				
Carbonate	CO_3	0							
Bicarbonate	HCO_3	85		Cyanide	CN				
Sulfate	SO_4	288		Phenols					
Chloride	Cl	291		M B A S					
Nitrate	NO_3	1.4		Grease & Oil					
Fluoride	F			Sulfides		< 2			
				Volatile Acids					
Boron	B			Suspended Solids					
Silica	SiO_2			Volatile Suspended Solids					
Iron	Fe			Dissolved Solids					
Manganese	Mn			Volatile Dissolved Solids					
Total Phosphate	PO_4			Settleable Solids					
Ortho Phosphate	PO_4			BOD, 5 day 20°C					
Nitrite	N	0		Oxygen Consumed					
Nitrate	N	0.31		Coliform, MPN/100 ml					
Ammonia	N	10		Plate Count/ml					
Total Organic Nitrogen	N			Plankton Count/ml					
Total Kjeldahl Nitrogen	N			Radioactivity Picocuries/ml					
Total Alkalinity	$CaCO_3$	70							
Total Hardness	$CaCO_3$								
Dissolved Solids									
Turbidity, Units									

Remarks: Results are from 1:1 extract except Ammonia and Sulfide

Approved Water Laboratory, California State Department of Public Health

Reported By: Robert R. Chambers

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P. O. BOX 81789, SAN DIEGO, CALIF. 92138

Sample Source: Imp Val 80-9-10-A
Hole 15 Bag Spt 2 , Depth: 6.5'

Benton Engineering
5540 Ruffin Rd.
San Diego, Ca 92123

Date November 10, 1980
Date Collected
Date Received October 20, 1980

Conductivity 1422 micromhos/cm @ 25°C
pH 8.51

Principal Constituents		mg/l	me/l			mg/l			mg/l
Cations:									
Calcium	Ca			Aluminum	Al		Barium	Ba	
Magnesium	Mg			Zinc	Zn		Cadmium	Cd	
Sodium	Na			Hexavalent Chromium	Cr		Silver	Ag	
Potassium	K			Total Chromium	Cr		Mercury	Hg	
Ammonia	NH_4	12		Arsenic	As		Gold	Au	
% Sodium				Lead	Pb				
				Copper	Cu				
Anions:				Selenium	Se				
Hydroxide	OH	0		Nickel	Ni				
Carbonate	CO_3	48							
Bicarbonate	HCO_3	24		Cyanide	CN				
Sulfate	SO_4	383		Phenols					
Chloride	Cl	243		M B A S					
Nitrate	NO_3	1.9		Grease & Oil					
Fluoride	F			Sulfides		< 2			
				Volatile Acids					
Boron	B			Suspended Solids					
Silica	SiO_2			Volatile Suspended Solids					
Iron	Fe			Dissolved Solids					
Manganese	Mn			Volatile Dissolved Solids					
Total Phosphate	PO_4			Settleable Solids					
Ortho Phosphate	PO_4			BOD, 5 day 20°C					
Nitrite	N	0		Oxygen Consumed					
Nitrate	N	0.44		Coliform, MPN/100 ml					
Ammonia	N	9.5		Plate Count/ml					
Total Organic Nitrogen	N			Plankton Count/ml					
Total Kjeldahl Nitrogen	N			Radioactivity Picocuries/ml					
Total Alkalinity	$CaCO_3$	140							
Total Hardness	$CaCO_3$								
Dissolved Solids									
Turbidity, Units									

Remarks Results are from 1:1 extract except Ammonia and Sulfide

Approved Water Laboratory, California State Department of Public Health

Reported By Robert K. Chambers

EN(VIR)ONMENTAL ENGINEERING LABORATORY
3538 HANCOCK STREET, SAN DIEGO, CALIF. 92110 • PHONE: 298-6131
P. O. BOX 81789, SAN DIEGO, CALIF. 92138

Benton Engineering
5540 Ruffin Rd.
San Diego, Ca 92123

Date: November 10, 1980
Date Collected:
Date Received: October 20, 1980

Sample Source: Imp Val 80-9-10-A
Hole 18 Bag 3 , 9' to 10'

Conductivity: 990 micromhos/cm @ 25°C
pH: 8.33

Principal Constituents		mg/l	me/l			mg/l			mg/l
Cations:									
Calcium	Ca			Aluminum	Al		Barium	Ba	
Magnesium	Mg			Zinc	Zn		Cadmium	Cd	
Sodium	Na			Hexavalent Chromium	Cr		Silver	Ag	
Potassium	K			Total Chromium	Cr		Mercury	Hg	
Ammonia	NH_4	7.6		Arsenic	As		Gold	Au	
% Sodium				Lead	Pb				
				Copper	Cu				
Anions:				Selenium	Se				
Hydroxide	OH	0		Nickel	Ni				
Carbonate	CO_3	40							
Bicarbonate	HCO_3	67		Cyanide	CN				
Sulfate	SO_4	251		Phenols					
Chloride	Cl	126		M B A S					
Nitrate	NO_3	3.8		Grease & Oil					
Fluoride	F			Sulfides		< 2			
				Volatile Acids					
Boron	B			Suspended Solids					
Silica	SiO_2			Volatile Suspended Solids					
Iron	Fe			Dissolved Solids					
Manganese	Mn			Volatile Dissolved Solids					
Total Phosphate	PO_4			Settleable Solids					
Ortho Phosphate	PO_4			BOD, 5 day 20°C					
Nitrite	N	0		Oxygen Consumed					
Nitrate	N	0.85		Coliform, MPN/100 ml					
Ammonia	N	5.9		Plate Count/ml					
Total Organic Nitrogen	N			Plankton Count/ml					
Total Kjeldahl Nitrogen	N			Radioactivity Picocuries/ml					
Total Alkalinity	$CaCO_3$	95							
Total Hardness	$CaCO_3$								
Dissolved Solids									
Turbidity, Units									

Remarks: Results are from 1:1 extract except Ammonia and Sulfide

Approved Water Laboratory, California State Department of Public Health

Reported By: Robert K. Chambers

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P. O. BOX 81789, SAN DIEGO, CALIF. 92138

Benton Engineering
5540 Ruffin Rd.
San Diego, Ca

Date November 10, 1980
Date Collected
Date Received October 20, 1980

Sample Source: Imp Val. 80-9-10-A
Hole 20 Bag Spt 1, Depth: 4'

Conductivity 1310 micromhos/cm @ 25°C
pH 7.91

Principal Constituents									
Cations:		mg/l	me/l			mg/l			mg/l
Calcium	Ca			Aluminum	Al		Barium	Ba	
Magnesium	Mg			Zinc	Zn		Cadmium	Cd	
Sodium	Na			Hexavalent Chromium	Cr		Silver	Ag	
Potassium	K			Total Chromium	Cr		Mercury	Hg	
Ammonia	NH_4	5.0		Arsenic	As		Gold	Au	
% Sodium				Lead	Pb				
				Copper	Cu				
Anions:				Selenium	Se				
Hydroxide	OH	0		Nickel	Ni				
Carbonate	CO_3	0							
Bicarbonate	HCO_3	92		Cyanide	CN				
Sulfate	SO_4	117		Phenols					
Chloride	Cl	399		M B A S					
Nitrate	NO_3	4.1		Grease & Oil					
Fluoride	F			Sulfides		< 2			
				Volatile Acids					
Boron	B			Suspended Solids					
Silica	SiO_2			Volatile Suspended Solids					
Iron	Fe			Dissolved Solids					
Manganese	Mn			Volatile Dissolved Solids					
Total Phosphate	PO_4			Settleable Solids					
Ortho Phosphate	PO_4			BOD, 5 day 20°C					
Nitrite	N	0		Oxygen Consumed					
Nitrate	N	0.92		Coliform, MPN/100 ml					
Ammonia	N	3.9		Plate Count/ml					
Total Organic Nitrogen	N			Plankton Count/ml					
Total Kjeldahl Nitrogen	N			Radioactivity Picocuries/ml					
Total Alkalinity	$CaCO_3$	75							
Total Hardness	$CaCO_3$								
Dissolved Solids									
Turbidity, Units									

Remarks Results are from 1:1 extract except Ammonia and Sulfide

Approved Water Laboratory, California State Department of Public Health

Reported By Robert L. Chambers

FUGRO, 1980

E-1 5-78

APPROVED BY

CHECKED BY

DEPTH IN FEET	SAMPLE TYPE	PENETRATION RESISTANCE	MOISTURE	DENSITY/ CONSISTENCY	COLOR	SOIL TYPE
0			Dry	Dense	Light brown	SILTY SAND (SM), fine to coarse, subangular to subrounded, strong HCl reaction; scattered pebbles
	S	36/12"				
5	S	18/12"		Medium dense to dense	Light gray brown	SAND (SP), fine to coarse, subangular to subrounded, moderately graded, strong HCl reaction; scattered granitic pebbles (13'-20')
10	S	20/12"				
15	S	45/12"				
20	S	12/12"	Moist to wet	Stiff	Brown	SILTY CLAY (CL), medium plasticity, mottled with caliche, strong HCl reaction; interbedded with silty sand (SM) at 26' and 30'
25	S	19/12"				
30	S	9/12"				
35	S	16/12"				CLAYEY SILT-SILTY CLAY (ML/CL) low plasticity mottled with caliche strong HCl reaction; micaceous
40						

● 10 20 30 40

▲ 90 100 110 120

ELEVATION: -8.43' DATE DRILLED: 10-24-79

EQUIPMENT USED: HOLLOW STEM AUGER

WATER LEVEL: NOT OBSERVED - HOLED CAVED IN AT 2'

[S] STANDARD SPLIT SPOON SAMPLE (ASTM D1586)

[D] FUGRO 2 1/2" DRIVE SAMPLE

[B] BULK SAMPLE

[T] THIN WALL TUBE SAMPLE (ASTM D1587)

▲ DRY DENSITY (LB/CU FT)

● FIELD MOISTURE (% DRY WT) (ASTM D2216)

NR NO RECOVERY

FUGRO

PROJECT NO: 79-199

SDG&E IMPERIAL SUBSTATION

LOG OF BORING NO. B-1
(SHEET 1 OF 2)

3-80

DEPTH IN FEET	SAMPLE TYPE	PENETRATION RESISTANCE	MOISTURE	DENSITY/ CONSISTENCY	COLOR	SOIL TYPE
40	S	13/12"	Moist	Stiff	Brown	SILTY CLAY-CLAYEY SILT (CL/ML), low to medium plasticity, mottled with caliche, strong HCl reaction; micaceous
45						
50	S	15/12"				
						BORING TERMINATED AT 51.5'
55						
60						
65						
70						
75						
80						

● 10 20 30 40

▲ 90 100 110 120

ELEVATION: -8.43' DATE DRILLED: 10-24-79

EQUIPMENT USED: HOLLOW STEM AUGER

WATER LEVEL: NOT OBSERVED-HOLE CAVED IN AT 2'

[S] STANDARD SPLIT SPOON SAMPLE (ASTM D1586)

[D] FUGRO 2 1/2" DRIVE SAMPLE

[B] BULK SAMPLE

[T] THIN WALL TUBE SAMPLE (ASTM D1587)

▲ DRY DENSITY (LB/CU FT)

● FIELD MOISTURE (% DRY WT) (ASTM D2216)

NR NO RECOVERY

FUGRO

PROJECT NO : 79-199

SDG&E IMPERIAL SUBSTATION

LOG OF BORING NO. B-1
(SHEET 2 OF 2)

3-80

COMPILED BY ____ DRAWN BY L. Nutz 12-80 CHECKED BY ____ APPROVED BY ____ E-1 5-78

DEPTH IN FEET	SAMPLE TYPE	PENETRATION RESISTANCE	MOISTURE	DENSITY/ CONSISTENCY	COLOR	SOIL TYPE
0			Dry	Dense	Light brown	SILTY SAND (SM), fine, subangular to subrounded, poorly graded, weak HCl reaction; scattered gastropod shells
	S	43/12"				
5	S	30/12"				
10	S	12/12"				
			Wet			
15	S	31/12"			Gray	SAND (SP), fine to medium, subangular to subrounded, poorly graded, no HCl reaction; numerous biotite flecks; interbedded with a thin layer of micaceous silty sand at 26'
20	S	32/12"				
25	S	36/12"				
30	S	19/12"	Moist	Very stiff	Brown	CLAY-SILTY CLAY (CH/CL), medium to high plasticity, caliche nodules, strong HCl reaction
35	S	17/12"				
40						

●	10	20	30	40
▲	90	100	110	120

ELEVATION: APPROX. 6.8'   DATE DRILLED: 10-23 & 24-79

EQUIPMENT USED: HOLLOW STEM AUGER

WATER LEVEL: ENCOUNTERED AT 12'

S STANDARD SPLIT SPOON SAMPLE (ASTM D1586)

D FUGRO 2 1/2" DRIVE SAMPLE

B BULK SAMPLE

T THIN WALL TUBE SAMPLE (ASTM D1587)

▲ DRY DENSITY (LB/CU FT)

● FIELD MOISTURE (% DRY WT) (ASTM D2216)

NR NO RECOVERY

FUGRO

PROJECT NO : 79-199

SDG&E IMPERIAL SUBSTATION

LOG OF BORING NO. B-2
(SHEET 1 OF 2)

3-80

COMPILED BY ____ DRAWN BY L. Ait 12-80 CHECKED BY ____ APPROVED BY ____ E-1 5-78

DEPTH IN FEET	SAMPLE TYPE	PENETRATION RESISTANCE	MOISTURE	DENSITY/ CONSISTENCY	COLOR	SOIL TYPE
40	S	22/12"	Moist	Very stiff to hard	Brown	CLAY-SILTY CLAY (CH/CL), medium to high plasticity, strong HCl reaction; interbedded with thin layers of sandy silty clay
50	S	38/12"				
						BORING TERMINATED AT 51.5'

Depth scale: 40, 45, 50, 55, 60, 65, 70, 75, 80

▲ 90 100 110 120

ELEVATION: -5.33'
DATE DRILLED: 10-23 & 24-79
EQUIPMENT USED: HOLLOW STEM AUGER
WATER LEVEL: ENCOUNTERED AT 12'

S STANDARD SPLIT SPOON SAMPLE (ASTM D1586)

D FUGRO 2 1/2" DRIVE SAMPLE

B BULK SAMPLE

T THIN WALL TUBE SAMPLE (ASTM D1587)

▲ DRY DENSITY (LB/CU FT)

● FIELD MOISTURE (% DRY WT) (ASTM D2216)

NR NO RECOVERY

FUGRO

PROJECT NO : 79-199

SDG&E IMPERIAL SUBSTATION

LOG OF BORING NO. B-2
(SHEET 2 OF 2)

3-80

E-1 5-78

COMPILED BY ___ DRAWN BY L. Nutz 1/2-80 CHECKED BY ___ APPROVED BY ___

DEPTH IN FEET	SAMPLE TYPE	PENETRATION RESISTANCE	MOISTURE	DENSITY/ CONSISTENCY	COLOR	SOIL TYPE
0			Dry	Medium dense to dense	Light brown	SILTY SAND (SM), fine, subangular to subrounded, poorly graded, strong HCl reaction; fossiliferous; trace of granitic fragments
	S	22/12"				
5	S	11/12"				
10	S	34/12"				
15	S	33/12"			Gray brown	SAND-SILTY SAND (SP/SM), fine to medium, subangular to subrounded, poorly to moderately well graded, weak HCl reaction, trace of coarse sand
20	S	18/12"				
			Wet			
25	S	12/12"				
30	S	40/12"		Dense to very dense	Gray	SAND (SP), fine to coarse, subangular to subrounded, poorly graded, no HCl reaction, some volcanic lithics; layer of gravelly sand at 35'; layer of very stiff silty clay at 37'
35	S	62 12"				
40						

● 10 20 30 40
▲ 90 100 110 120

ELEVATION: -3.08'
DATE DRILLED: 10-23-79
EQUIPMENT USED: HOLLOW STEM AUGER
WATER LEVEL: ENCOUNTERED AT 22'

S STANDARD SPLIT SPOON SAMPLE (ASTM D1586)
D FUGRO 2 1/2" DRIVE SAMPLE
B BULK SAMPLE
T THIN WALL TUBE SAMPLE (ASTM D1587)
▲ DRY DENSITY (LB/CU FT)
● FIELD MOISTURE (% DRY WT) (ASTM D2216)
NR NO RECOVERY

FUGRO

PROJECT NO : 79-199

SDG&E IMPERIAL SUBSTATION

LOG OF BORING NO. B-3
(SHEET 1 OF 2)

3-80

E-1 5-78

COMPILED BY / DRAWN BY L. Sutz 1-2-80 CHECKED BY / APPROVED BY /

DEPTH IN FEET	SAMPLE TYPE	PENETRATION RESISTANCE	MOISTURE	DENSITY/ CONSISTENCY	COLOR	SOIL TYPE
40	S	35/12"	Wet	Dense	Gray	SAND (SP), fine to medium, subangular to subrounded, poorly graded, no HCl reaction; trace of lithic fragments
50	S	9/12"	Moist	Very stiff	Brown	CLAY-SILTY CLAY (CH/CL), medium to high plasticity, strong HCl reaction
						BORING TERMINATED AT 51.5'

Depth scale: 40, 45, 50, 55, 60, 65, 70, 75, 80

● 10 20 30 40
▲ 90 100 110 120

ELEVATION: -3.08'
DATE DRILLED: 10-23-79
EQUIPMENT USED: HOLLOW STEM AUGER
WATER LEVEL: ENCOUNTERED AT 22'

S STANDARD SPLIT SPOON SAMPLE (ASTM D1586)

D FUGRO 2 1/2" DRIVE SAMPLE

B BULK SAMPLE

T THIN WALL TUBE SAMPLE (ASTM D1587)

▲ DRY DENSITY (LB/CU FT)

● FIELD MOISTURE (% DRY WT) (ASTM D2216)

NR NO RECOVERY

FUGRO

PROJECT NO : 79-199

SDG&E IMPERIAL SUBSTATION

LOG OF BORING NO. B-3
(SHEET 2 OF 2)

3-80

COMPILED BY ___ DRAWN BY L. Kurtz 1/2-80 CHECKED BY ___ APPROVED BY ___ E-1 5-78

DEPTH IN FEET	SAMPLE TYPE	PENETRATION RESISTANCE	MOISTURE	DENSITY/ CONSISTENCY	COLOR	SOIL TYPE
0			Dry	Medium dense	Gray brown	SILTY SAND-SANDY CLAY (SM/CL), fine to medium, poorly graded, medium plasticity, some biotites, no HCl reaction
	S	18/12"				
5	S	26/12"			Light brown	SILTY SAND (SM), fine, subangular to subrounded, poorly graded, strong HCl reaction; some granitic lithics and biotites
10	S	21/12"	Moist			
15	S	23/12"			Gray brown	SAND-SILTY SAND (SP/SM), fine to medium, subangular to subrounded poorly graded non to weak HCl reaction; some biotites and granitic fragments
			Wet			
20	S	16/12"				
					Gray	
25	S	30/12"				
30	S	22/12"				
35	S	22/12"				
40						

Chart scales: ● 10 20 30 40; ▲ 90 100 110 120

ELEVATION: -11.05' DATE DRILLED: 10-22-79
EQUIPMENT USED: HOLLOW STEM AUGER
WATER LEVEL: ENCOUNTERED AT 18'

S STANDARD SPLIT SPOON SAMPLE (ASTM D1586)
D FUGRO 2 1/2" DRIVE SAMPLE
B BULK SAMPLE
T THIN WALL TUBE SAMPLE (ASTM D1587)
▲ DRY DENSITY (LB/CU FT)
● FIELD MOISTURE (% DRY WT) (ASTM D2216)
NR NO RECOVERY

FUGRO

PROJECT NO : 79-199

SDG&E IMPERIAL SUBSTATION

LOG OF BORING NO. B-4
(SHEET 1 OF 2)

3-80

E-1 5-78

COMPILED BY ___ DRAWN BY 1. Nute 12-80 CHECKED BY ___ APPROVED BY ___

DEPTH IN FEET	SAMPLE TYPE	PENETRATION RESISTANCE	MOISTURE	DENSITY/ CONSISTENCY	COLOR	SOIL TYPE
40	S	24/12"	Wet	Dense to very dense	Gray brown	SAND-SILTY SAND (SP/SM), fine to medium, subangular to subrounded, poorly graded, weak HCl reaction
50	S	54/12"				
						BORING TERMINATED AT 51.5'

Depth scale: 40, 45, 50, 55, 60, 65, 70, 75, 80

● 10 20 30 40
▲ 90 100 110 120

ELEVATION: -11.05'
DATE DRILLED: 10-22-79
EQUIPMENT USED: HOLLOW STEM AUGER
WATER LEVEL: ENCOUNTERED AT 18'

[S] STANDARD SPLIT SPOON SAMPLE (ASTM D1586)
[D] FUGRO 2 1/2" DRIVE SAMPLE
[B] BULK SAMPLE
[T] THIN WALL TUBE SAMPLE (ASTM D1587)
▲ DRY DENSITY (LB/CU FT)
● FIELD MOISTURE (% DRY WT) (ASTM D2216)
NR NO RECOVERY

FUGRO

PROJECT NO : 79-199

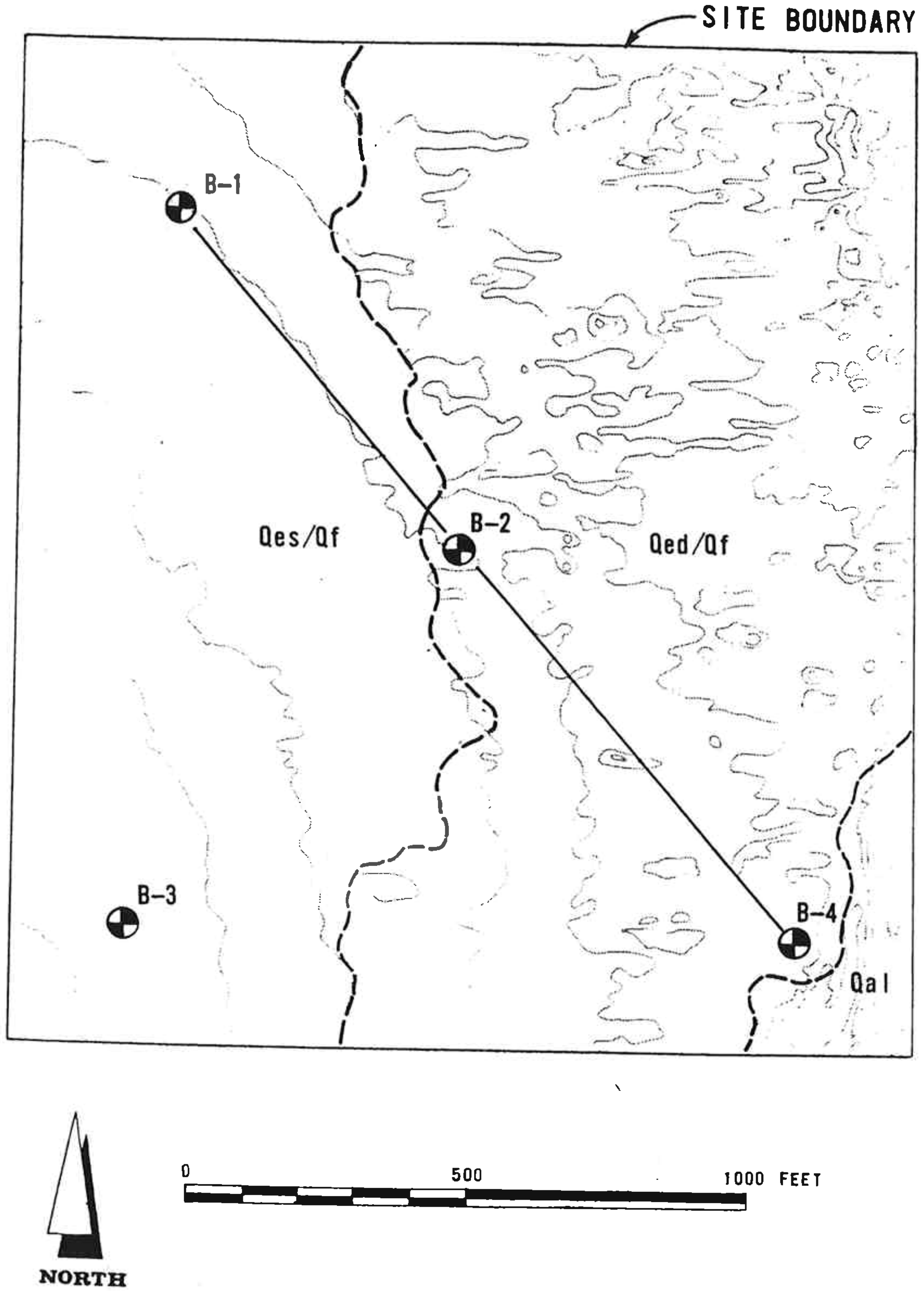
SDG&E IMPERIAL SUBSTATION

LOG OF BORING NO. B-4
(SHEET 2 OF 2)

3-80

COMPILED BY ___ DRAWN BY L Hw3 / 2-80 CHECKED BY ___ APPROVED BY ___ / / E-1 3-73

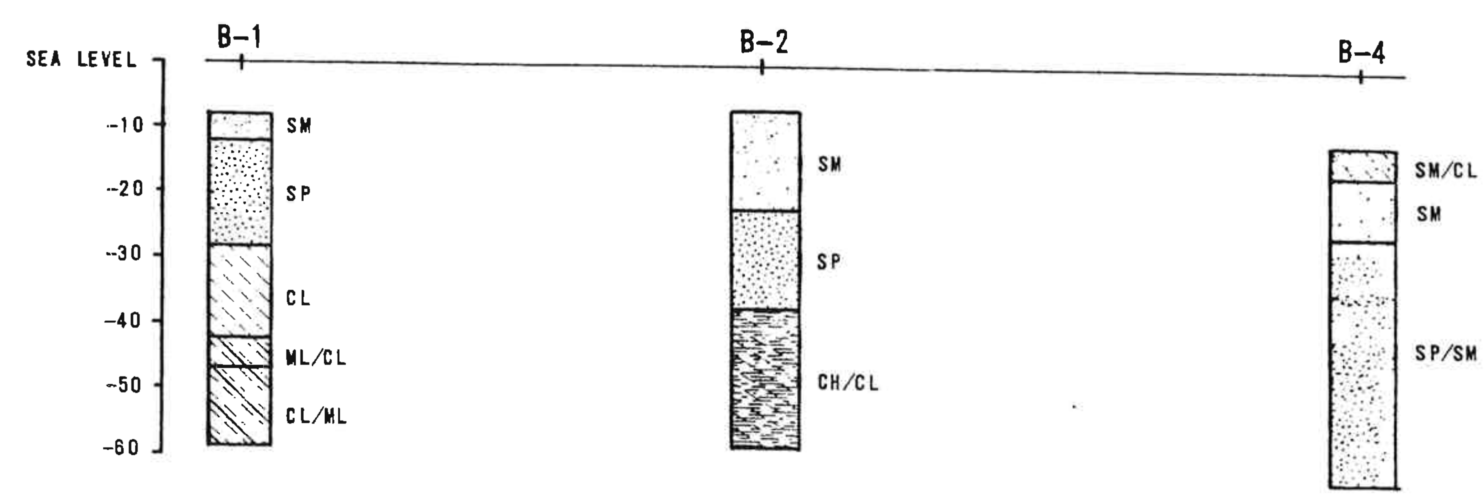
FUGRO



EXPLANATION

Qes/Qf	YOUNG ALLUVIAL FAN MANTLED BY EOLIAN SHEET SAND DEPOSITS
Qed/Qf	YOUNG ALLUVIAL FAN MANTLED BY EOLIAN DUNE DEPOSITS
Qal	MODERN STREAM CHANNEL AND FLOOD DEPOSITS
	TOPOGRAPHIC CONTOURS - IN FEET BELOW SEA LEVEL
— — — —	GEOLOGIC CONTACT- APPROXIMATELY LOCATED

CROSS SECTION



HORIZONTAL SCALE 1" = 300'
VERTICAL SCALE 1" = 30'
VERTICAL EXAGGERATION: 10X

FUGRO

PROJECT NO : 79-199

SDG&E IMPERIAL SUBSTATION

SURFICIAL GEOLOGIC MAP
AND CROSS SECTION

4-80

FIGURE 3

URS, 2003

Project: SDG&E Imperial Valley Substation Project Location: Imperial County, California Project Number: 27643870.00001	**Key to Logs** Sheet 1 of 1

Elevation, feet	Depth, feet	SAMPLES: Type	SAMPLES: Number	SAMPLES: Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
1	2	3	4	5	6	7	8	9	10

COLUMN DESCRIPTIONS

1 **Elevation:** Elevation in feet referenced to mean sea level (MSL) or site datum.

2 **Depth:** Depth in feet below the ground surface.

3 **Sample Type:** Type of soil sample collected at depth interval shown; sampler symbols are explained below.

4 **Sample Number:** Sample identification number. Unnumbered sample indicates no sample recovery.

5 **Sampling Resistance:** Number of blows required to advance driven sampler 12 inches beyond first 6-inch interval, or distance noted, using a 140-lb hammer with a 30-inch drop.

6 **Graphic Log:** Graphic depiction of subsurface material encountered; typical symbols are explained below.

7 **Material Description:** Description of material encountered; may include relative density/consistency, moisture, color, particle size; texture, weathering, and strength of formation material.

8 **Water Content:** Water content of soil sample measured in laboratory, expressed as percentage of dry weight of specimen.

9 **Dry Unit Weight:** Dry density of soil sample measured in laboratory, in pounds per cubic foot.

10 **Remarks and Other Tests:** Comments and observations regarding drilling or sampling made by driller or field personnel.

LL	Liquid limit, %
PI	Plasticity Index, %; NP=nonplastic
SA	Sieve analysis (%<#200 sieve)
WA	Three-point wash sieve (%<#200 sieve)
UC	Unconfined compressive strength test (Qu in ksf)
ATD	At time of drilling

TYPICAL MATERIAL GRAPHIC SYMBOLS

Silty SAND (SM)

Sand

SAND with silt

SILT

CLAY

Fat CLAY (CH)

TYPICAL SAMPLER GRAPHIC SYMBOLS

Sample collected in a bag or bucket

2.5-inch-OD Modified California sampler

OTHER GRAPHIC SYMBOLS

First water encountered at time of drilling and sampling (ATD)

Water level measured at specified time after completion of drilling and sampling

Minor change in material properties within a stratum

Inferred or gradational contact between strata

GENERAL NOTES

1. Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive; actual lithologic changes may be gradual. Field descriptions may have been modified to reflect results of lab tests.

2. Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced. They are not warranted to be representative of subsurface conditions at other locations or times.

Project: SDG&E Imperial Valley Substation
Project Location: Imperial County, California
Project Number: 27643870.00001

Log of Boring B-1

Date(s) Drilled	**11/7/02**	Logged By	**S. Fitzwilliam**	Checked By	**S. Fitzwilliam**
Drilling Method	**Hollow Stem Auger**	Drill Bit Size/Type	**8"**	Total Depth of Borehole	**31 feet**
Drill Rig Type	**Mobile B-61**	Drilling Contractor	**F&C Drilling**	Approximate Surface Elevation	
Water Level Depth (Feet)	**None encountered**	Sampling Method(s)	**Bulk/ModCal**	Hammer Data	**140#/30" drop**
Borehole Backfill	**Soil cuttings**	Location	**See Site Plan**		

Elevation, feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
	0					FILL Dry to moist, light brown, sandy gravel (up to 2")			
	2		1-1			EOLIAN DEPOSITS Very dense, dry to moist, medium brown, poorly graded medium to fine SAND (SP)			
	4					Becomes coarse to fine with few gravels and trace clay			
	6		1-2	87					
	8					ALLUVIAL/LACUSTRINE DEPOSITS Very dense, moist, light brown to medium brown, poorly graded medium to fine SAND with silt (SP-SM)			
	10		1-3	50		Very dense, moist, light brown, fine sandy SILT (ML), with thin interbeds of silty clay	11	102	WA(99), UC(4)
	12								
	14								
	16		1-4	70			5	90	
	18		1-5						
	20					Very hard, moist, medium brown, silty fat CLAY (CH)			

Report: GEO_10_SNA; File: 27643870.GPJ; 8/28/2008 B-1

URS

Figure A-2

Project: SDG&E Imperial Valley Substation
Project Location: Imperial County, California
Project Number: 27643870.00001

Log of Boring B-1

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
	20		1-6	65					LL=71, PI=47
	22								
	24					Becomes lean to fat clay			
			1-7	50/6"		Very dense, dry to moist, pale brown, poorly graded very fine SAND (SP)	4		WA(18)
	26								
	28								
	30		1-8	50/6"					
	32					Bottom of Boring at 31 feet			
	34								
	36								
	38								
	40								
	42								

URS

Figure A-2

Project: SDG&E Imperial Valley Substation
Project Location: Imperial County, California
Project Number: 27643870.00001

Log of Boring B-2

Date(s) Drilled	**11/7/02**	Logged By	**S. Fitzwilliam**	Checked By	**S. Fitzwilliam**
Drilling Method	**Hollow Stem Auger**	Drill Bit Size/Type	**8"**	Total Depth of Borehole	**31.5 feet**
Drill Rig Type	**Mobile B-61**	Drilling Contractor	**F&C Drilling**	Approximate Surface Elevation	
Water Level Depth (Feet)	**None encountered**	Sampling Method(s)	**Bulk/ModCal**	Hammer Data	**140#/30" drop**
Borehole Backfill	**Soil cuttings**	Location	**See Site Plan**		

Elevation, feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
	0					FILL Dry to moist, pale light brown, sandy gravel (up to 2")			
	2					EOLIAN DEPOSITS Very dense, dry to moist, medium brown, poorly graded coarse to fine SAND (SP) with trace gravel Becomes light brown medium to fine sand			
	4								
	6		2-1	33		ALLUVIAL/LACUSTRINE DEPOSITS Very stiff to hard, moist, medium brown to yellow brown, sandy lean CLAY (CL) with trace silt			
			2-2						
	8					Very dense, moist, light brown, fine sandy SILT (ML)			
	10		2-3	66		Very hard, moist, medium brown to yellow brown, lean CLAY (CL) with fine sand			
	12					Very dense, moist, light brown, fine sandy SILT (ML), with thin interbeds of silty clay			
	14								
	16		2-4	55					
	18								
						Very dense, moist, light brown, fine sandy lean CLAY (CL)			
	20								

Report: GEO_10_SNA; File: 27643870.GPJ; 8/28/2008 B-2

URS

Figure A-3

Project: SDG&E Imperial Valley Substation
Project Location: Imperial County, California
Project Number: 27643870.00001

Log of Boring B-2

Elevation, feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
	20		2-5	74		Very dense, moist, light brown, fine sandy SILT (ML)			SA(98)
	22								
	24								
			2-6	50/6"		Very dense, moist, pale brown, poorly graded very fine SAND (SP)			
	26								
			2-8						
	28								
	30		2-7	54		Very dense, moist to wet, brown, silty fine SAND (SM) with thin clay interbeds	23	101	
	32					Bottom of Boring at 31.5 feet			
	34								
	36								
	38								
	40								
	42								

URS

Project: SDG&E Imperial Valley Substation **Project Location: Imperial County, California** **Project Number: 27643870.00001**	**Log of Boring B-3** Sheet 1 of 2

Date(s) Drilled	**11/7/02**	Logged By	**S. Fitzwilliam**	Checked By	**S. Fitzwilliam**
Drilling Method	**Hollow Stem Auger**	Drill Bit Size/Type	**8"**	Total Depth of Borehole	**37 feet**
Drill Rig Type	**Mobile B-61**	Drilling Contractor	**F&C Drilling**	Approximate Surface Elevation	
Water Level Depth (Feet)	**34 feet**	Sampling Method(s)	**Bulk/ModCal**	Hammer Data	**140#/30" drop**
Borehole Backfill	**Soil cuttings**	Location	**See Site Plan**		

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
	0					FILL Dry to moist, light brown, sandy gravel (up to 2")			
	2		3-1			EOLIAN DEPOSITS Very dense, dry to moist, light brown, poorly graded coarse to fine SAND (SP) with trace gravel Becoming medium to fine sand			
	4		3-2	41		ALLUVIAL/LACUSTRINE DEPOSITS Hard, moist, brown to yellow brown, medium to fine sandy lean CLAY (CL)	14	109	
	8		3-3	50/6"		Very dense, moist, light brown, fine sandy SILT (ML)			
	12		3-4						
	14		3-5	77		Very hard, moist, brown to yellow brown, lean CLAY (CL) with fine sand	18	111	UC(18)
	19					Very dense, moist, light brown, fine sandy SILT (ML)			
	20								

Report: GEO_10_SNA; File: 27643870.GPJ; 8/28/2008 B-3

Figure A-4

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Log of Boring B-3

Elevation, feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
	20		3-6	90/10"					
	22								
						Becomes brown to yellow brown			
	24								
							22	101	SA(100)
	26		3-7	58		Becomes wet			
	28					With thin interbeds of clay and silty sand			
	30		3-8	64					
	32								
	34					∇			
	36								
	38					Bottom of Boring at 37 feet			
	40								
	42								

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Our field investigation included the drilling and sampling of eight hollow stem auger test borings (Borings B-1 through B-8) advanced between June 2 and 9, 2008. Three additional mud rotary borings were advanced immediately adjacent to Borings B-3, B-6, and B-7 to facilitate pressuremeter testing. Pacific Drilling of San Diego, California performed the drilling. The borings were supervised and logged by an engineering geologist from our firm. The borings were backfilled soil cuttings and bentonite chips. The approximate boring locations are shown on Figure 2.

The locations of the borings were approximated a handheld Global Positioning System (GPS) unit and the plans provided to us. SDG&E provided ground surface elevation information for each of the boring locations. A Key to Logs is presented as Figure B-1. Final logs of the borings are presented on Figures B-2 through B-9. The descriptions on the boring logs are based on field logs, sample inspections, and results of laboratory tests.

Samples of the subsurface materials were obtained using Standard Penetration Test (SPT) or modified California samplers. Grab samples were also collected of the soil cuttings. Where the modified California sampler was used, the blowcounts on the boring logs have been corrected to indicate SPT N values by multiplying the field blowcount by a factor of 0.8. The samples were sealed to preserve the natural moisture content and returned to our laboratory for examination and testing. The results of laboratory tests are shown at the corresponding sample location on the boring logs and in Appendix D.

Project: SDG&E - Imperial Valley Substation
Project Location: Imperial Valley, CA
Project Number: 27668011.00010

Key to Logs

Elevation, feet	Depth, feet	SAMPLES: Type	SAMPLES: Number	SAMPLES: Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
1	2	3	4	5	6	7	8	9	10

COLUMN DESCRIPTIONS

1 **Elevation:** Elevation in feet referenced to mean sea level (MSL) or site datum.

2 **Depth:** Depth in feet below the ground surface.

3 **Sample Type:** Type of soil sample collected at depth interval shown; sampler symbols are explained below.

4 **Sample Number:** Sample identification number. Unnumbered sample indicates no sample recovery.

5 **Sampling Resistance:** Number of blows required to advance driven sampler 12 inches beyond first 6-inch interval, or distance noted, using a 140-lb hammer with a 30-inch drop.

6 **Graphic Log:** Graphic depiction of subsurface material encountered; typical symbols are explained below.

7 **Material Description:** Description of material encountered; may include relative density/consistency, moisture, color, particle size; texture, weathering, and strength of formation material.

8 **Water Content:** Water content of soil sample measured in laboratory, expressed as percentage of dry weight of specimen.

9 **Dry Unit Weight:** Dry density of soil sample measured in laboratory, in pounds per cubic foot.

10 **Remarks and Other Tests:** Comments and observations regarding drilling or sampling made by driller or field personnel.

LL	Liquid limit (from Atterberg limits test), %
PI	Plasticity Index [LL - PL], %; NP=nonplastic
SA	Sieve analysis (%<#200 sieve)
WA	Three-point wash sieve (%<#200 sieve)
HYD	Hydrometer (%<#200 sieve)
DS	Direct Shear Test
CORR	Corrosion Test Suite
COMP	Laboratory Compaction
UU	Unconsolidated Undrained Compression Test

TYPICAL MATERIAL GRAPHIC SYMBOLS

- Silty SAND (SM)
- Poorly graded SAND (SP)
- SAND with clay (SP-SC)
- SAND with silt (SP-SM)
- SILT (ML)
- High plasticity SILT (MH)
- Lean CLAY (CL)
- Fat CLAY (CH)
- Lean to fat CLAY (CL/CH)
- SILT/CLAY (ML/CL)
- Clayey SAND (SC)

TYPICAL SAMPLER GRAPHIC SYMBOLS

- Bulk sample
- Modified California sampler
- Standard Penetration Test sampler

OTHER GRAPHIC SYMBOLS

- First water encountered at time of drilling and sampling (ATD)
- Water level measured at specified time after completion of drilling and sampling
- Minor change in material properties within a stratum
- Inferred or gradational contact between strata

GENERAL NOTES

1. Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive; actual lithologic changes may be gradual. Field descriptions may have been modified to reflect results of lab tests.

2. Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced. They are not warranted to be representative of subsurface conditions at other locations or times.

3. Reported blows per foot are SPT-N values. Blowcounts for samples obtained with the Modified California sampler were reduced by a factor of 0.8.

URS

Log of Boring B-1

Project: SDG&E - Imperial Valley Substation
Project Location: Imperial Valley, CA
Project Number: 27668011.00010

Date(s) Drilled	**06/03/08**	Logged By	**A. Podawiltz**	Checked By	**K. Giesing**
Drilling Method	**Hollow Stem Auger**	Drill Bit Size/Type	**3.25" ID/7" OD finger bit**	Total Depth of Borehole	**51.5 feet**
Drill Rig Type	**Unimog Marl M5**	Drilling Contractor	**Pacific Drilling**	Approximate Surface Elevation	**6.60 feet, MSL**
Water Level Depth (Feet)	**None encountered**	Sampling Method(s)	**SPT/ModCal**	Hammer Data	**140 lbs/30" drop**
Borehole Backfill	**Soil cuttings and bentonite**	Location	**N 3621016 E 620286**		

Elevation, feet	Depth, feet	SAMPLES: Type	SAMPLES: Number	SAMPLES: Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
	0					ALLUVIAL/LACUSTRINE DEPOSITS Very dense, dry, light brown, poorly graded SAND with clay (SP-SC), some gravel, reacts moderately to HCl			
5									
			1-1	73			2		CORR
	5		1-2	38		Dense, dry, light brown, fine, poorly graded SAND (SP), trace silt	1	105	
0									
						Very stiff, dry, brown fat CLAY (CH), reacts strongly with HCl			
	10		1-3	20					CORR
-5									
						Hard, dry, brown CLAY (CL), high silt content, reacts weakly with HCl			
	15		1-4	31					
-10									
						Becomes very stiff, decreased silt content, reacts very strongly with HCl			
	20		1-5	23					
-15									
						Becomes hard, moist, increased silt content, trace sand, reacts very weakly with HCl			
	25		1-6	35			4	95	
-20									
	30								

Report: GEO_10_SNA; File: 27668011.GPJ; 10/9/2008 B-1

Project: SDG&E - Imperial Valley Substation
Project Location: Imperial Valley, CA
Project Number: 27668011.00010

Log of Boring B-1

Elevation, feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
	30		1-7	18		Becomes very stiff, decreased silt content			CORR
-25						Medium dense, moist, yellowish brown, fine sandy CLAY/SILT (CL/ML)			
	35		1-8	42		Becomes very dense, wet, increased sand content	20	105	
-30									
						Stiff, wet, brown CLAY (CL/CH)			
	40		1-9	13					
-35									
	45		1-10	14			30	91	
-40									
	50		1-11	19		Becomes very stiff			
-45						Bottom of boring at 51.5 feet			
	55								
-50									
	60								
-55									
	65								

URS

Project: SDG&E - Imperial Valley Substation **Project Location: Imperial Valley, CA** **Project Number: 27668011.00010**	# Log of Boring B-2 Sheet 1 of 2

Date(s) Drilled	**06/03/08**	Logged By	**A. Podawiltz**	Checked By	**K. Giesing**
Drilling Method	**Hollow Stem Auger**	Drill Bit Size/Type	**3.25" ID/7" OD finger bit**	Total Depth of Borehole	**51.5 feet**
Drill Rig Type	**Unimog Marl M5**	Drilling Contractor	**Pacific Drilling**	Approximate Surface Elevation	**5.74 feet, MSL**
Water Level Depth (Feet)	**None encountered**	Sampling Method(s)	**SPT/ModCal**	Hammer Data	**140 lbs/30" drop**
Borehole Backfill	**Soil cuttings and bentonite**	Location	**N 3620962 E 620334**		

Elevation, feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
5	0					ALLUVIAL/LACUSTRINE DEPOSITS Very dense, dry, light brown, fine, poorly graded SAND with clay (SP-SC), trace gravel 0 to 2.5'			
			2-1	60					WA(12)
0	5		2-2	13		Stiff, dry, brown, lean CLAY (CL)	13	98	WA(98), UU
-5	10		2-3	24		Very stiff, dry, light brown, fat CLAY (CH)	13		
						Hard, dry, brown, lean CLAY (CL), high silt content, reacts weakly to HCl			
-10	15		2-4	32			3	98	DS
-15	20		2-5	20		Becomes very stiff, red-brown, decreased silt content, reacts very strongly with HCl			
-20	25		2-6	22		Becomes moist, light brown, increased silt content, reacts strongly with HCl	8	101	WA(85), UU
	30								

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Project: SDG&E - Imperial Valley Substation Project Location: Imperial Valley, CA Project Number: 27668011.00010	Log of Boring B-2 Sheet 2 of 2

Elevation, feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
-25	30		2-7	33		Hard, dry, brown, fine sandy CLAY/SILT (CL/ML)	4		
-30	35		2-8	21		Becomes very stiff, moist, decreased silty content			
						Increased silt content			
						Stiff, wet, brown CLAY (CL/CH)			
-35	40		2-9	13			28		
-40	45		2-10	16		Becomes very stiff, moist			
-45	50		2-11	19					
						Bottom of boring at 51.5 feet			
-50	55								
-55	60								
	65								

Project: SDG&E - Imperial Valley Substation **Project Location: Imperial Valley, CA** **Project Number: 27668011.00010**	# Log of Boring B-3 Sheet 1 of 2

Date(s) Drilled	**06/03/08**	Logged By	**A. Podawiltz**	Checked By	**K. Giesing**
Drilling Method	**Hollow Stem Auger**	Drill Bit Size/Type	**3.25" ID/7" OD finger bit**	Total Depth of Borehole	**51.5 feet**
Drill Rig Type	**Unimog Marl M5**	Drilling Contractor	**Pacific Drilling**	Approximate Surface Elevation	**7.12 feet, MSL**
Water Level Depth (Feet)	**None encountered**	Sampling Method(s)	**SPT/ModCal**	Hammer Data	**140 lbs/30" drop**
Borehole Backfill	**Soil cuttings and bentonite**	Location	**N 3620849 E 620256**		

Elevation, feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
	0					ALLUVIAL/LACUSTRINE DEPOSITS Very dense, dry, light brown, medium to fine, clayey SAND (SC), trace fine sand to gravel, some silt, reacts strongly to HCl			
5			3-1	63			4		WA(19)
	5		3-2	18		Becomes medium dense, contains zones of lean CLAY (CL)	5	116	DS, CORR
0									
						Very stiff, dry, brown, fat CLAY (CH), trace lenses of fine sand and silt, reacts very strongly to HCl			
	10		3-3	17			16		LL(65), PI(45)
-5									
						Hard, dry, light brown, lean CLAY (CL), high silt content			
	15		3-4	35			3		WA(93)
-10						Becomes brown, decreased silt content			
	20		3-5	22			11		LL(41), PI(26)
						Becomes light brown, increased silt content			
-15									
	25		3-6	22			6	94	WA(89), UU
-20									
	30								

Project: SDG&E - Imperial Valley Substation
Project Location: Imperial Valley, CA
Project Number: 27668011.00010

Log of Boring B-3

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
	30		3-7	15		Becomes moist, decreased silt content	25		LL(45), PI(29)
-25						Stiff, wet, light brown CLAY/SILT (CL/ML)			
	35		3-8	12			27	98	HYD(98), LL(31), PI(9)
-30									
	40		3-9	14		Some sand, decreased silt content, reacts strongly to HCl			
-35									
	45		3-10	6		Medium stiff, wet, brown, lean CLAY (CL)	25	102	WA(95), LL(39), PI(24), UU
-40									
	50								
-45						Bottom of boring at 51.5 feet			
	55								
-50									
	60								
-55									
	65								

URS

Project: SDG&E - Imperial Valley Substation
Project Location: Imperial Valley, CA
Project Number: 27668011.00010

Log of Boring B-4

Date(s) Drilled	**06/09/08**	Logged By	**A. Podawiltz**	Checked By	**K. Giesing**
Drilling Method	**Hollow Stem Auger**	Drill Bit Size/Type	**3.25" ID/7" OD finger bit**	Total Depth of Borehole	**51.5 feet**
Drill Rig Type	**Unimog Marl M5**	Drilling Contractor	**Pacific Drilling**	Approximate Surface Elevation	**6.06 feet, MSL**
Water Level Depth (Feet)	**None encountered**	Sampling Method(s)	**SPT/ModCal**	Hammer Data	**140 lbs/30" drop**
Borehole Backfill	**Soil cuttings and bentonite**	Location	**N 3620884 E 620336**		

Elevation, feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
5	0					ALLUVIAL/LACUSTRINE DEPOSITS Very dense, dry, light brown, medium to coarse, poorly graded silty SAND (SM), with gravel			
			4-1	53					
			4-1a						SA(21), COMP
0	5		4-2	23		Very stiff, dry, brown, lean CLAY (CL), with organics			
-5	10		4-3	18		Very stiff, dry, light brown SILT (ML), with clay			
						Hard, dry, brown, fat CLAY (CH)			
-10	15		4-4	39		Hard, dry, light brown CLAY (CL), high silt content			
						Becomes very stiff, brown, decreased silt content			
-15	20		4-5	18		Becomes light brown, increased silt content			
-20	25		4-6	21		Becomes brown, decreased silt content			
	30								

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Figure B-5

Log of Boring B-4

Elevation, feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
-25	30		4-7	21		Very stiff, moist, light brown CLAY/SILT (CL/ML)			
-30	35		4-8	27		Becomes wet			
						Very stiff, wet, brown, lean to fat CLAY (CL/CH)			
-35	40		4-9	14					
-40	45		4-10	10		Becomes stiff	8		SA(99), LL(49), PI(33)
-45	50		4-11	17		Becomes very stiff			
						Bottom of boring at 51.5 feet			
-50	55								
-55	60								
	65								

Project: SDG&E - Imperial Valley Substation
Project Location: Imperial Valley, CA
Project Number: 27668011.00010

Log of Boring B-5

Date(s) Drilled	**06/09/08**	Logged By	**A. Podawiltz**	Checked By	**K. Giesing**
Drilling Method	**Hollow Stem Auger**	Drill Bit Size/Type	**3.25" ID/7" OD finger bit**	Total Depth of Borehole	**51.5 feet**
Drill Rig Type	**Unimog Marl M5**	Drilling Contractor	**Pacific Drilling**	Approximate Surface Elevation	**7.68 feet, MSL**
Water Level Depth (Feet)	**None encountered**	Sampling Method(s)	**SPT/ModCal**	Hammer Data	**140 lbs/30" drop**
Borehole Backfill	**Soil cuttings and bentonite**	Location	**N 3620669 E 620239**		

Elevation, feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
	0					ALLUVIAL/LACUSTRINE DEPOSITS Medium dense, dry, light brown, fine to medium, poorly graded SAND with silt (SP-SM)			
5			5-1	22					
	5		5-2	17		Decreased silt content			
0									
	10		5-3	20					
-5						Dense, dry, light brown, silty fine SAND (SM)			
	15		5-4	24					
-10						Very stiff, dry, light brown, lean CLAY (CL), high silt content			
	20		5-5	22					
-15									
	25		5-6	19		Becomes moist			
-20									
	30								

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Project: SDG&E - Imperial Valley Substation
Project Location: Imperial Valley, CA
Project Number: 27668011.00010

Log of Boring B-5

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
	30		5-7	19		Becomes wet, brown, decreased silt content			
-25						Increased silt content, with fine sand			
	35		5-8	19					
-30						Very stiff, wet, brown, sandy lean CLAY (CL)			
	40		5-9	17		Very stiff, wet, brown SILT/CLAY (ML/CL), with fine sand	27		SA(70), LL(26), PI(9)
-35									
	45		5-10	12					
-40						Becomes hard, decreased sand content			
	50		5-11	30					
						Bottom of boring at 51.5 feet			
-45									
	55								
-50									
	60								
-55									
	65								

URS

Figure B-6

Project: SDG&E - Imperial Valley Substation **Project Location: Imperial Valley, CA** **Project Number: 27668011.00010**	**Log of Boring B-6** Sheet 1 of 2

Date(s) Drilled	**06/02/08**	Logged By	**A. Podawiltz**	Checked By	**K. Giesing**
Drilling Method	**Hollow Stem Auger**	Drill Bit Size/Type	**3.25" ID/7" OD finger bit**	Total Depth of Borehole	**51.5 feet**
Drill Rig Type	**Unimog Marl M5**	Drilling Contractor	**Pacific Drilling**	Approximate Surface Elevation	**7.25 feet, MSL**
Water Level Depth (Feet)	**None encountered**	Sampling Method(s)	**SPT/ModCal**	Hammer Data	**140 lbs/30" drop**
Borehole Backfill	**Soil cuttings and bentonite**	Location	**N 3620658 E 620279**		

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
	0					ALLUVIAL/LACUSTRINE DEPOSITS Medium dense, dry, light brown, medium to fine SAND with silt (SP-SM)			
5			6-1	22					SA(14)
	5		6-2	14		Becomes medium to coarse	1	115	WA(4), DS
0									
						Dense, dry, light brown, medium to fine silty SAND (SM), with lenses of coarse, poorly graded sand, reacts weakly with HCl, some clay			
	10		6-3	36					CORR
-5									
	15		6-4	26		Becomes medium dense, decreased clay content	2	106	WA(6), DS
-10									
						Very stiff, dry, light brown, sandy CLAY (CL), high silt content, reacts strongly with HCl			
	20		6-5	24					HYD(69)
-15									
	25		6-6	32		Hard, moist, brown, lean CLAY (CL)	2	98	
						Dense, moist, light brown, medium to coarse, poorly graded SAND (SP), some oxidation			
-20									
	30								

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Figure B-7

Project: SDG&E - Imperial Valley Substation	Log of Boring B-6
Project Location: Imperial Valley, CA	Sheet 2 of 2
Project Number: 27668011.00010	

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
	30		6-7	14		Stiff, wet, brown, lean CLAY (CL)			HYD(98), LL(47), PI(31)
-25						Decreased clay content			
	35		6-8	14			27	97	
						Stiff, wet, brown, fat CLAY (CH)			
-30									
						Very stiff, wet, brown SILT/CLAY (ML/CL)			
	40		6-9	20					
-35									
	45					Varying sand content			
			6-10	15			27	96	WA(100), LL(29), PI(6), DS
-40									
	50		6-11	16					
						Bottom of boring at 51.5 feet			
-45									
	55								
-50									
	60								
-55									
	65								

Report: GEO_10_SNA; File: 27668011.GPJ; 10/9/2008 B-6

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Project: SDG&E - Imperial Valley Substation
Project Location: Imperial Valley, CA
Project Number: 27668011.00010

Log of Boring B-7

Date(s) Drilled	**06/02/08**	Logged By	**A. Podawiltz**	Checked By	**K. Giesing**
Drilling Method	**Hollow Stem Auger**	Drill Bit Size/Type	**3.25" ID/7" OD finger bit**	Total Depth of Borehole	**51.5 feet**
Drill Rig Type	**Unimog Marl M5**	Drilling Contractor	**Pacific Drilling**	Approximate Surface Elevation	**9.80 feet, MSL**
Water Level Depth (Feet)	**35**	Sampling Method(s)	**SPT/ModCal**	Hammer Data	**140 lbs/30" drop**
Borehole Backfill	**Soil cuttings and bentonite**	Location	**N 3620525 E 620179**		

Elevation, feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
	0					ALLUVIAL/LACUSTRINE DEPOSITS Medium dense, dry, light brown, fine poorly graded silty SAND (SM) trace gravels, reacts strongly with HCl			
			7-1	20			1		CORR
5	5		7-2	18		Increased silt content, trace clay			WA(27)
						Medium dense, dry, light brownish white, medium to coarse, poorly graded SAND (SP)			
0	10		7-3	15			2		
-5	15		7-4	21					WA(5)
-10	20		7-5	22		Becomes medium to fine, reacts strongly with HCl	1		
						Very stiff, moist, brown, fine sandy CLAY (CL)			
-15	25		7-6	18					
-20	30								

URS

Figure B-8

Project: SDG&E - Imperial Valley Substation
Project Location: Imperial Valley, CA
Project Number: 27668011.00010

Log of Boring B-7

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
	30		7-7	32		Dense, moist, brown, fine poorly graded SAND with silt (SP-SM), reacts strongly with HCl	3	99	SA(6)
-25	35		7-8	29		Becomes medium dense, wet ▽			
-30	40		7-9	14		Stiff, wet, brown, fat CLAY (CH), trace clayey sand lenses and trace organics, reacts strongly with HCl			
-35	45		7-10	19		Very stiff, wet, brown SILT/CLAY (ML/CL), trace sand			
-40	50		7-11	24					
						Bottom of boring at 51.5 feet			
-45	55								
-50	60								
-55	65								

Report: GEO_10_SNA; File: 27668011.GPJ; 10/9/2008 B-7

URS

Project: SDG&E - Imperial Valley Substation **Project Location: Imperial Valley, CA** **Project Number: 27668011.00010**	**Log of Boring B-8** Sheet 1 of 2

Date(s) Drilled	**06/09/08**	Logged By	**A. Podawiltz**	Checked By	**K. Giesing**
Drilling Method	**Hollow Stem Auger**	Drill Bit Size/Type	**3.25" ID/7" OD finger bit**	Total Depth of Borehole	**51.5 feet**
Drill Rig Type	**Unimog Marl M5**	Drilling Contractor	**Pacific Drilling**	Approximate Surface Elevation	**8.40 feet, MSL**
Water Level Depth (Feet)	**36.3**	Sampling Method(s)	**SPT/ModCal**	Hammer Data	**140 lbs/30" drop**
Borehole Backfill	**Soil cuttings and bentonite**	Location	**N 3620527 E 620275**		

Elevation, feet	Depth, feet	SAMPLES: Type	SAMPLES: Number	SAMPLES: Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
840	0					ALLUVIAL/LACUSTRINE DEPOSITS Medium dense, dry, light brown, fine to medium, poorly graded SAND with silt (SP-SM)			
			8-1	20					
835	5		8-2	26		Becomes dense			
						Stiff, dry, light brown, sandy lean CLAY (CL)			
830	10		8-3	14			8		WA(53)
						Dense, dry, light brown, fine to medium, silty SAND (SM)			
825	15		8-4	27					
						Medium dense, dry, light brown, medium to coarse, poorly graded SAND with silt (SP-SM)			
820	20		8-5	17					WA(8)
815	25		8-6	20		Becomes moist			
810	30								

Project: SDG&E - Imperial Valley Substation Project Location: Imperial Valley, CA Project Number: 27668011.00010	Log of Boring B-8 Sheet 2 of 2

Elevation, feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
810	30		8-7	35		Becomes dense			
805	35		8-8	16		Becomes medium dense, wet, with gravel, increased silt content	13	108	SA(15) Water level recorded in temporary piezometer
						Stiff, wet, brown to dark brown, fat CLAY (CH)			
800	40		8-9	22					
						Hard, wet, brown to dark brown SILT /CLAY (ML/CL), trace fine sand			
795	45		8-10	29					
						Becomes very stiff			
790	50		8-11	20					
						Bottom of boring at 51.5 feet			
785	55								
780	60								
775	65								

This appendix presents the results of 18 prebored pressuremeter tests conducted adjacent to Boring B-3, Boring B-7, and Boring B-8. Pressuremeter test borings were advanced using rotary wash equipment approximately 7 feet away from the primary hollow stem auger geotechnical borings. When possible, pressuremeter tests were performed at the same depths as the driven geotechnical samples in the adjacent borehole to facilitate correlation of SPT N-values to pressuremeter modulus. Testing was done in general accordance with ASTM Test Standard D4719.

The pressuremeter test is a loading test carried out in situ in a borehole. For prebored pressuremeter tests, an inflatable cylindrical probe attached to drill rods is set at the selected test depth in a borehole predrilled below the bottom of the probe. The pressuremeter then uses a hydraulic control unit to load and monitor the soil response. The data collected defines the stress-strain relationship of the soil. The pressuremeter data is used to determine the limit pressure and the pressuremeter modulus.

The results of this test method are dependent on the degree of disturbance during drilling of the borehole and insertion of the pressuremeter probe. Since disturbance cannot be completely eliminated, the interpretation of the test results should include consideration of drilling conditions. This disturbance is particularly significant in very soft clays and very loose sands.

EQUIPMENT

A TEXAM pressuremeter manufactured by Roctest Ltd. was used to complete all pressuremeter tests. This pressuremeter uses a monocellular, hydraulically inflated probe. A piston displaces a controlled volume of water into a 74-millimeter diameter pressuremeter probe. This piston is housed in the control unit and is advanced by an actuator attached to the control unit. Pressure is measured by pressure gauges on the control unit. Teclan tubing is used to connect the probe to the control unit. Additional equipment information can be found on Roctest’s website.

PRESSUREMETER TESTING

The pressuremeter test borings were advanced using a 2-15/16-inch drag bit and rotary wash methods. To achieve a boring of uniform diameter within the prescribed tolerances (between 1.03 and 1.2 times the uninflated probe diameter) and reduce borehole disturbance, pump speeds and rod advancement rates were closely monitored. Typically, the boring was advanced approximately 3.5 feet beyond the desired test depth (center of the probe) to allow space for drill cuttings not evacuated by the drilling mud to settle prior to insertion of the test probe. Following a test, the borehole was advanced to a depth sufficient to conduct the next pressuremeter test.

Calibration of the pressuremeter system for compressibility and probe membrane resistance was done prior to transport to the site. Further calibrations were completed in the field during testing and after completion of the pressuremeter test in Boring B-3 (the first test location). The control box was also routinely checked for accumulated air, which is sometimes generated during testing.

In general, testing was performed with little difficulty, though the drillers had trouble maintaining fluid circulation while drilling pressuremeter Boring B-3. In some instances, the probe was mechanically advanced using static weight or light down pressure using the drill rig hydraulics. This was necessary likely due to relaxation of borehole walls.

The pressuremeter tests were performed following ASTM Test Standard D4719 Procedure B, in which the pressuremeter is inflated in increments of equal volume. Volume increments of 80 cubic centimeters were introduced into the probe and pressure readings were recorded after 30 seconds. In addition, unload-reload cycles were performed at some locations. Readings were recorded manually and entered into a spreadsheet that performs data corrections and calculations.

DATA REDUCTION

The pressuremeter test data was reduced using Pressio Companion V.15 by Roctest Ltd. 2007. The program uses the raw data recorded in the field and applies appropriate corrections. A pressuremeter plot is generated using the corrected data. Typical plots consist of three zones. The first zone is where the probe has not made contact with the borehole wall. This occurs in the initial loading increments and is seen as a relatively small pressure increase with increasing volume. The second zone is the linear portion of the plot. This segment represents the pseudo-elastic behavior of the tested material and is used to compute the pressuremeter modulus. Poisson's ratio is assumed to be 0.33 for all soils in the calculations of this modulus (Briaud 1992). The third portion of the plot will generally show an acceleration of deformation towards the failure point, which is reflected as a decreasing pressure increase for successive increments of equal volume increase. This portion of the plot represents plastic deformation of the soil and is used to define the limit pressure.

Table C-1, Summary of Pressuremeter Test Results, presents a summary of the pressuremeter test results. Figures C-1 through C-18 present the data for each test, a plot of the data, and the values of the pressuremeter modulus, limit pressure and yield pressure.

The pressuremeter testing was intended to provide in situ engineering properties of the specific materials and locations tested. Test results should not be construed as representative for the entire site due to variations in subsurface materials. These variations occur both vertically and horizontally. The data and values presented do not reflect any conservatism or factors of safety, which may be appropriate for design.

Table C-1
Summary of Pressuremeter Test Results
Imperial Valley Substation

Location	Depth (ft)	Test ID	E_{pmt} (ksi)	Unload Modulus E_{ul} (psi)	Reload Modulus E_{rl} (psi)	Ultimate Pressure P_L (psi)	Yield Pressure P_F (psi)	E/P_L	P_L/P_F	Nearest Sample		
										Sample Depth[1] (ft)	SPT N[2]	USCS[3]
B-3	4.5	3-1	1.89	4,843	4,372	215	123	8.83	1.74	6	*18*	SC
B-3	9.5	3-2	2.19	8,873	7,950	236	95	9.28	2.50	11	17	CL
B-3	16.5	3-3	1.76	6,737	6,100	233	100	7.56	2.32	16	*35*	ML
B-3	21	3-4	1.41	6,642	5,490	191	78	7.38	2.46	21	22	CL
B-3	26	3-5	3.01	18,690	15,850	353	143	8.52	2.47	26	*22*	CL
B-3	31.5	3-6	1.53	5,740	4,810	170	77	9.01	2.20	31	15	CL
B-3	36	3-7	1.51	10,260	6,810	316	211	4.78	1.50	36	*12*	CL
B-6	5	6-1	1.45	N/A	N/A	N/A	86	N/A	N/A	6	*14*	SP-SM
B-6	11	6-2	1.21	14,580	12,190	251	124	4.82	2.01	11	36	SM
B-6	15	6-3	1.60	N/A	N/A	309	123	5.18	2.50	16	*26*	SM
B-6	21	6-4	2.73	N/A	N/A	382	170	7.15	2.25	21	24	ML
B-6	31	6-5	1.87	N/A	N/A	232	121	8.06	1.91	31	14	CL
B-7	4.5	7-1	1.56	12,880	11,320	218	108	7.15	2.01	6	18	SP-SM
B-7	11	7-2	0.92	N/A	N/A	N/A	48	N/A	N/A	11	*15*	SP
B-7	16	7-3	1.33	16,490	14,320	217	145	6.15	1.50	16	21	SP
B-7	21	7-4	1.52	19,870	17,050	282	172	5.37	1.64	21	*22*	SP
B-7	31	7-5	4.65	N/A	N/A	436	171	10.68	2.55	31	*32*	SP-SM

Notes:
1. Reported sample depth to the center of the interval over which the blow count was determined.
2. Modified California blow counts were multiplied by 0.8 to convert to an equivalent SPT N value.
3. Unified Soil Classification System group symbol.

TEXAM Pressuremeter Test

Project name: Imperial substation
Borehole name: B-3
Test date: (mm/dd/yyyy) 06/11/2008
Test number: 3-1
Probe size: N

Use of a slotted casing: No
Test depth: 4.50 ft
Manometer height above ground: 1.64 ft
Poisson's coefficient: 0.33
Fluid density: 1.000

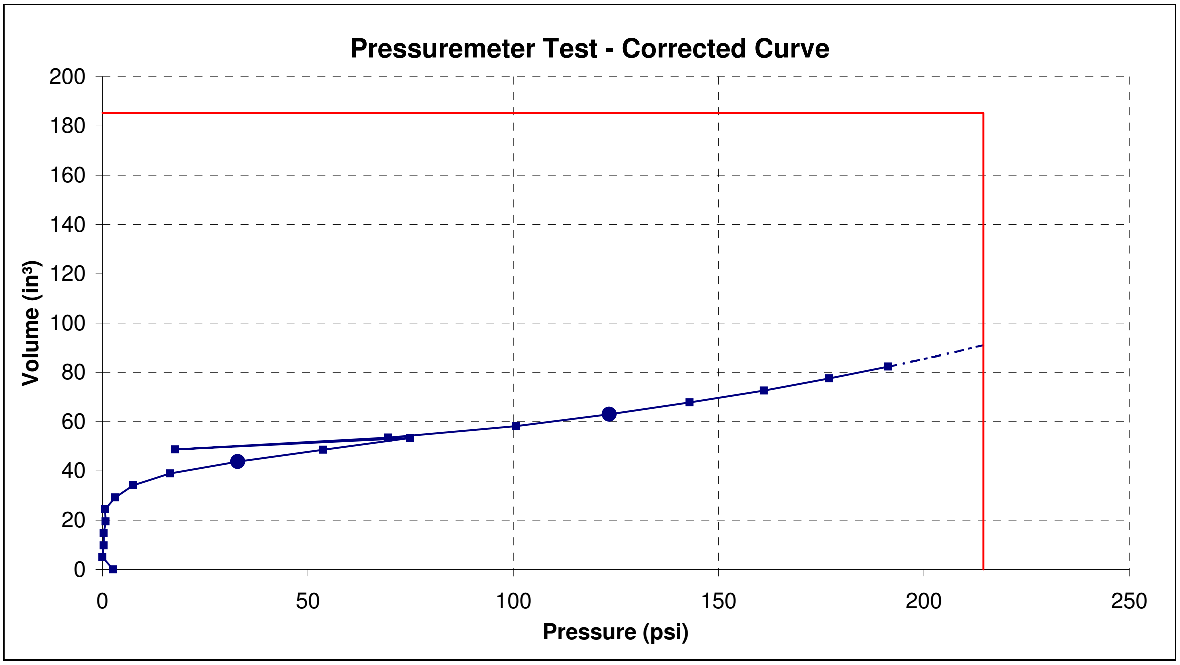
Raw Readings		Corrected Readings			
Pressure psi	Volume in³	Pressure psi	Volume in³	$\Delta R/R_0$ %	
0	0.0	3	0.0	0.00	
0	4.9	0	4.9	2.47	
1	9.8	0	9.8	4.88	
1	14.6	0	14.6	7.23	
2	19.5	1	19.5	9.53	
3	24.4	1	24.4	11.79	
6	29.3	3	29.3	14.00	
11	34.2	7	34.1	16.16	
20	39.1	16	39.0	18.28	
36	43.9	33	43.8	20.34	◄
57	48.8	54	48.6	22.37	
78	53.7	75	53.4	24.37	
21	48.8	18	48.7	22.42	
73	53.7	70	53.4	24.37	
104	58.6	101	58.2	26.32	
127	63.5	123	63.0	28.25	◄
146	68.3	143	67.8	30.16	
165	73.2	161	72.6	32.04	
181	78.1	177	77.5	33.89	
195	83.0	191	82.3	35.73	

Test Results

Pressiometric modulus E:	1,893 psi
Unload Modulus	4843 psi
Reload Modulus	4372 psi
Ultimate pressure P_L:	215 psi
Yield pressure P_F:	123 psi
Ratio E / P_L:	8.83
Ratio P_L / P_F:	1.74

Calibration Sheet Reference

Remarks



ROCTEST TELEMAC

PRESSIO COMPANION V.15

Figure: C-1

TEXAM Pressuremeter Test

Project name:	Imperial substation	Use of a slotted casing:	No
Borehole name:	B-3	Test depth:	9.50 ft
Test date: (mm/dd/yyyy)	06/11/2008	Manometer height above ground:	1.64 ft
Test number:	3-2	Poisson's coefficient:	0.33
Probe size:	N	Fluid density:	1.000

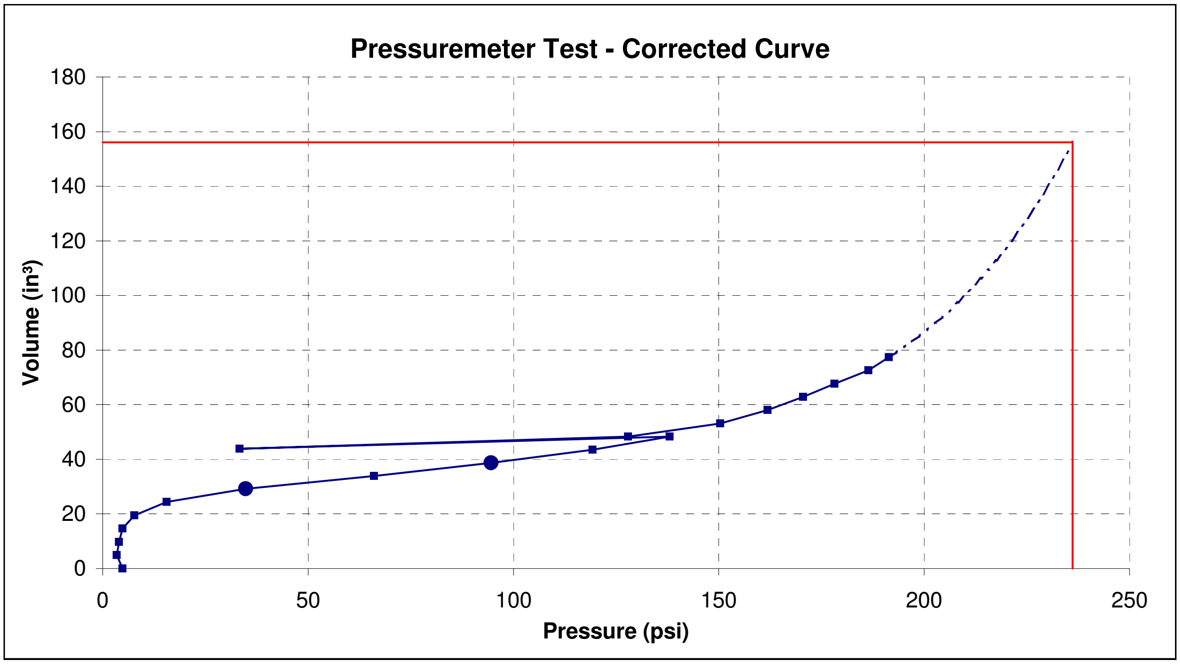
Raw Readings		Corrected Readings			
Pressure psi	Volume in³	Pressure psi	Volume in³	$\Delta R/R_0$ %	
0	0.0	5	0.0	0.00	
1	4.9	3	4.9	2.46	
2	9.8	4	9.8	4.87	
4	14.6	5	14.6	7.23	
7	19.5	8	19.5	9.52	
16	24.4	16	24.4	11.77	
36	29.3	35	29.2	13.95	◄
67	34.2	66	33.9	16.07	
96	39.1	95	38.7	18.16	◄
120	43.9	119	43.5	20.22	
139	48.8	138	48.3	22.25	
35	43.9	33	43.8	20.35	
129	48.8	128	48.4	22.27	
152	53.7	150	53.2	24.26	
163	58.6	162	58.0	26.24	
172	63.5	171	62.9	28.19	
180	68.3	178	67.7	30.11	
188	73.2	186	72.6	32.01	
193	78.1	191	77.4	33.88	

Test Results

Pressiometric modulus E:	2,191 psi
Unload Modulus	8873 psi
Reload Modulus	7950 psi
Ultimate pressure P_L:	236 psi
Yield pressure P_F:	95 psi
Ratio E / P_L:	9.28
Ratio P_L / P_F:	2.50

Calibration Sheet Reference

Remarks



TEXAM Pressuremeter Test

Project name:	Imperial substation	Use of a slotted casing:	No
Borehole name:	B-3	Test depth:	16.50 ft
Test date: (mm/dd/yyyy)	06/11/2008	Manometer height above ground:	1.64 ft
Test number:	3-3	Poisson's coefficient:	0.33
Probe size:	N	Fluid density:	1.000

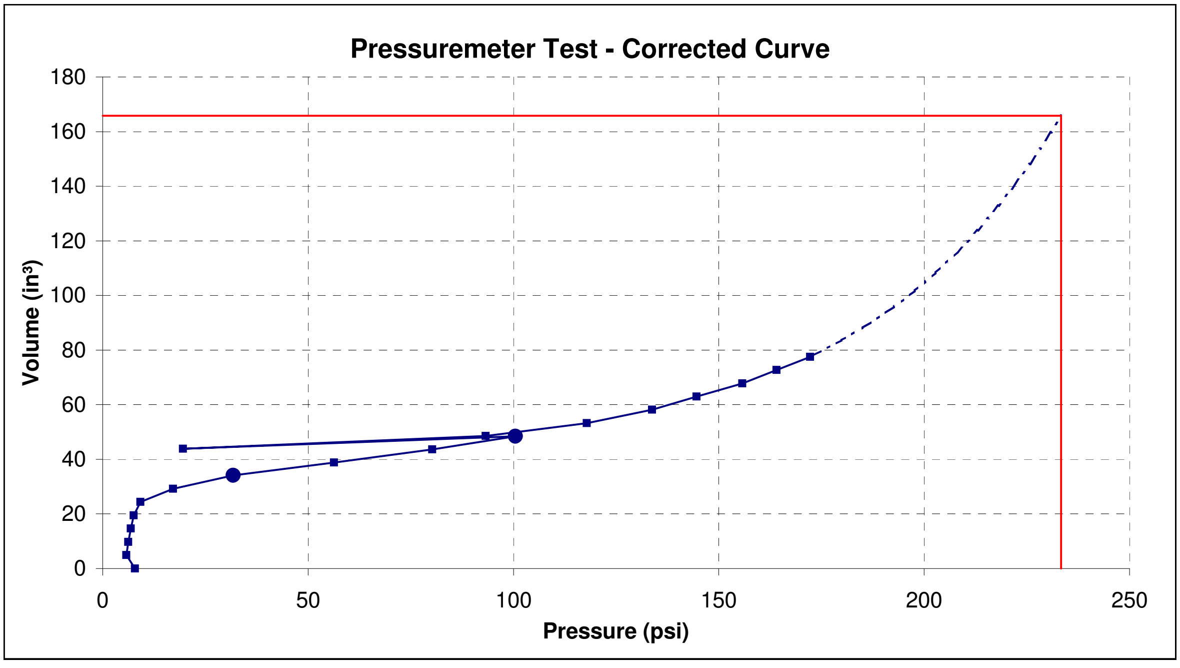
Raw Readings		Corrected Readings			
Pressure psi	Volume in³	Pressure psi	Volume in³	$\Delta R/R_0$ %	
0	0.0	8	0.0	0.00	
1	4.9	6	4.9	2.47	
1	9.8	6	9.8	4.87	
3	14.6	7	14.6	7.23	
4	19.5	8	19.5	9.53	
7	24.4	9	24.4	11.78	
15	29.3	17	29.2	13.98	
30	34.2	32	34.1	16.13	◄
54	39.1	56	38.9	18.22	
78	43.9	80	43.7	20.28	
99	48.8	100	48.5	22.31	◄
18	43.9	20	43.9	20.37	
91	48.8	93	48.5	22.32	
116	53.7	118	53.3	24.31	
132	58.6	134	58.1	26.28	
143	63.5	145	63.0	28.23	
154	68.3	156	67.8	30.15	
162	73.2	164	72.7	32.04	
171	78.1	172	77.5	33.91	

Test Results

Pressiometric modulus E:	1,764 psi
Unload Modulus	6,737 psi
Reload Modulus	6,100 psi
Ultimate pressure P_L:	233 psi
Yield pressure P_F:	100 psi
Ratio E / P_L:	7.56
Ratio P_L / P_F:	2.32

Calibration Sheet Reference

Remarks



ROCTEST TELEMAC

PRESSIO COMPANION V.15

Figure: C-3

TEXAM Pressuremeter Test

Project name:	Imperial substation	Use of a slotted casing:	No
Borehole name:	B-3	Test depth:	21.00 ft
Test date: (mm/dd/yyyy)	06/11/2008	Manometer height above ground:	1.64 ft
Test number:	3-4	Poisson's coefficient:	0.33
Probe size:	N	Fluid density:	1.000

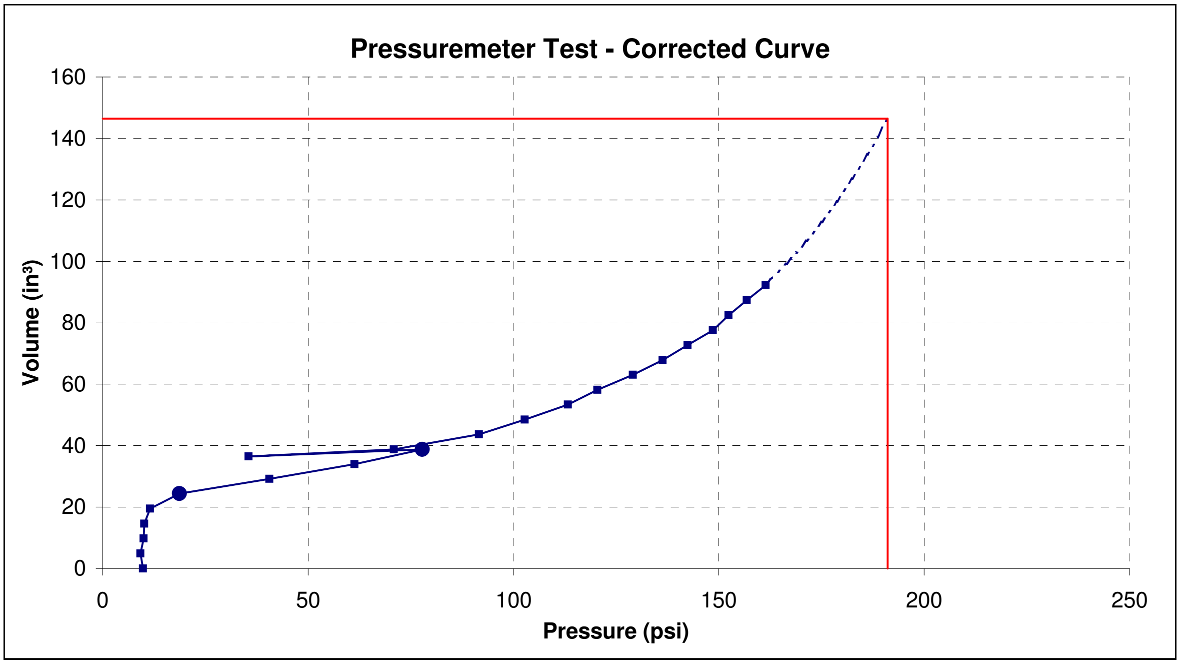
Raw Readings		Corrected Readings			
Pressure psi	Volume in³	Pressure psi	Volume in³	$\Delta R/R_0$ %	
0	0.0	10	0.0	0.00	
2	4.9	9	4.9	2.46	
3	9.8	10	9.8	4.87	
4	14.6	10	14.6	7.22	
6	19.5	12	19.5	9.53	
14	24.4	19	24.4	11.77	◄
36	29.3	41	29.2	13.95	
57	34.2	61	34.0	16.09	
74	39.1	78	38.8	18.19	◄
32	36.6	36	36.5	17.20	
67	39.1	71	38.8	18.20	
88	43.9	92	43.6	20.27	
99	48.8	103	48.5	22.31	
110	53.7	113	53.3	24.32	
117	58.6	120	58.2	26.30	
125	63.5	129	63.0	28.25	
133	68.3	136	67.9	30.18	
139	73.2	142	72.7	32.07	
145	78.1	149	77.6	33.94	
149	83.0	152	82.5	35.79	
153	87.9	157	87.3	37.61	
158	92.8	161	92.2	39.41	

Test Results

Pressiometric modulus E:	1,410 psi
Unload Modulus	6,642 psi
Reload Modulus	5,490 psi
Ultimate pressure P_L:	191 psi
Yield pressure P_F:	78 psi
Ratio E / P_L:	7.38
Ratio P_L / P_F:	2.46

Calibration Sheet Reference

Remarks



ROCTEST TELEMAC

PRESSIO COMPANION V.15

Figure: C-4

TEXAM Pressuremeter Test

Project name:	Imperial substation	Use of a slotted casing:	No
Borehole name:	B-3	Test depth:	26.00 ft
Test date: (mm/dd/yyyy)	06/11/2008	Manometer height above ground:	1.64 ft
Test number:	3-5	Poisson's coefficient:	0.33
Probe size:	N	Fluid density:	1.000

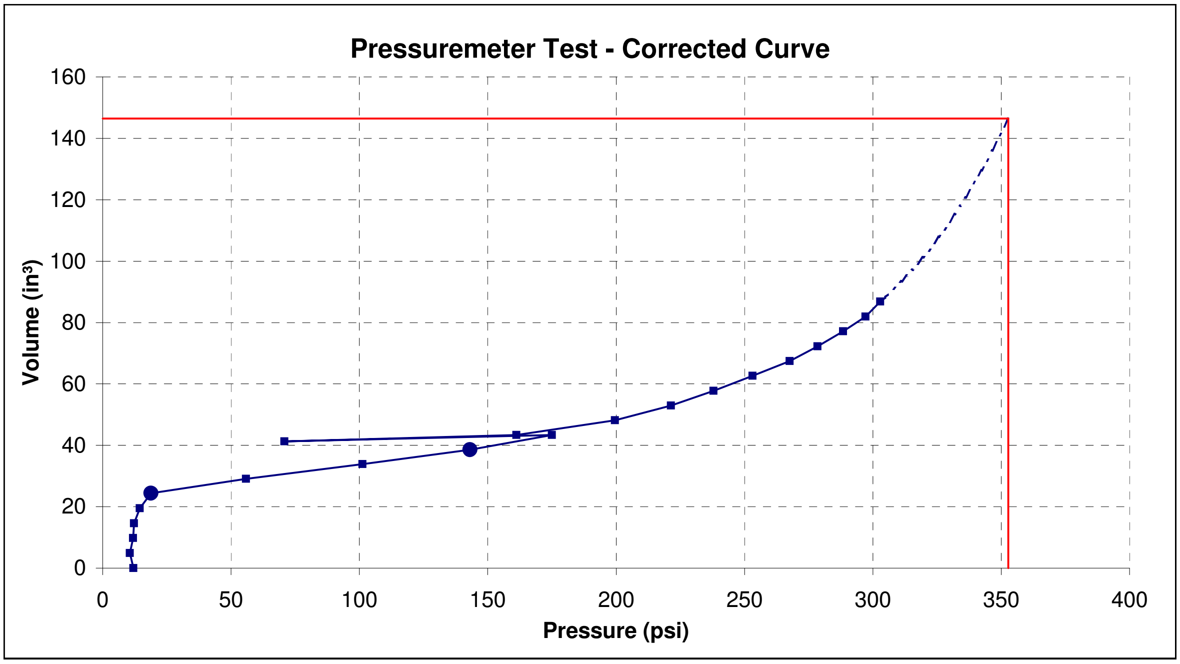
Raw Readings		Corrected Readings			
Pressure psi	Volume in³	Pressure psi	Volume in³	$\Delta R/R_0$ %	
0	0.0	12	0.0	0.00	
1	4.9	11	4.9	2.46	
3	9.8	12	9.8	4.87	
4	14.6	12	14.6	7.22	
7	19.5	14	19.5	9.52	
12	24.4	19	24.4	11.77	◄
49	29.3	56	29.1	13.93	
95	34.2	101	33.8	16.03	
137	39.1	143	38.6	18.10	◄
169	43.9	175	43.3	20.15	
65	41.5	71	41.3	19.26	
155	43.9	161	43.4	20.17	
194	48.8	200	48.1	22.17	
215	53.7	221	52.9	24.17	
232	58.6	238	57.8	26.14	
247	63.5	253	62.6	28.08	
262	68.3	268	67.4	30.00	
273	73.2	278	72.3	31.89	
283	78.1	288	77.1	33.76	
292	83.0	297	82.0	35.60	
297	87.9	303	86.8	37.42	

Test Results

Pressiometric modulus E:	3,007 psi
Unload Modulus	18,690 psi
Reload Modulus	15,850 psi
Ultimate pressure P_L:	353 psi
Yield pressure P_F:	143 psi
Ratio E / P_L:	8.52
Ratio P_L / P_F:	2.47

Calibration Sheet Reference

Remarks



ROCTEST TELEMAC

PRESSIO COMPANION V.15

Figure: C-5

TEXAM Pressuremeter Test

Project name:	Imperial substation	Use of a slotted casing:	No
Borehole name:	B-3	Test depth:	31.50 ft
Test date: (mm/dd/yyyy)	06/12/2008	Manometer height above ground:	1.64 ft
Test number:	3-6	Poisson's coefficient:	0.33
Probe size:	N	Fluid density:	1.000

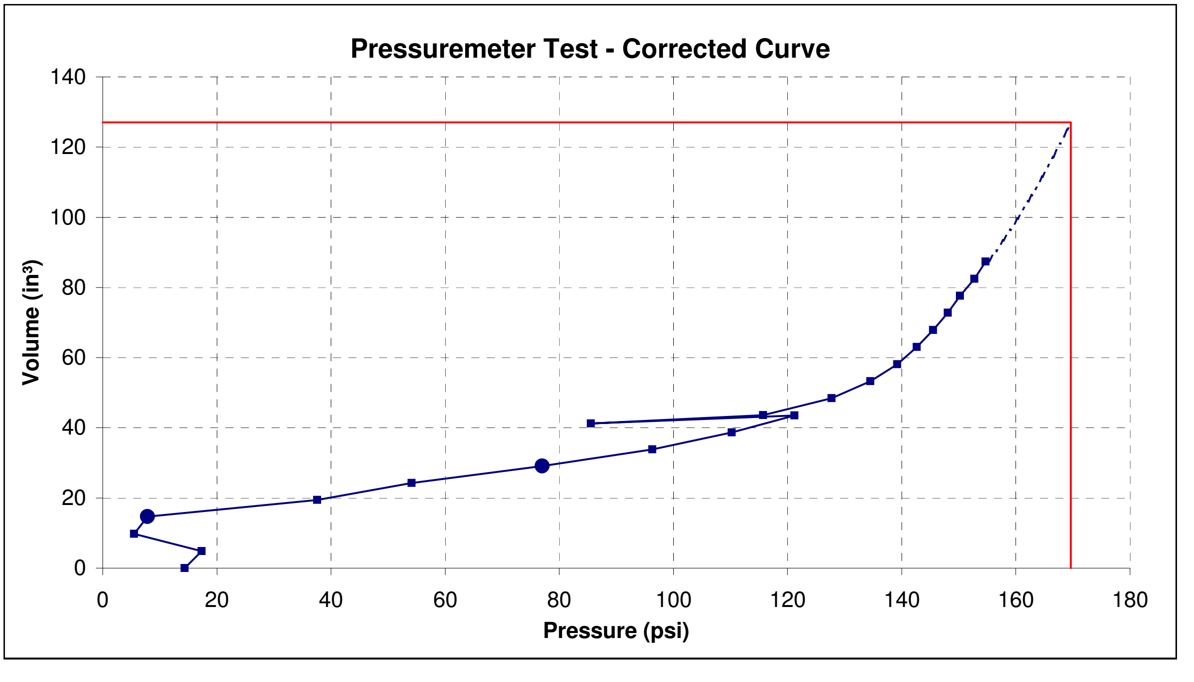
Raw Readings		Corrected Readings			
Pressure psi	Volume in³	Pressure psi	Volume in³	$\Delta R/R_0$ %	
0	0.0	14	0.0	0.00	
6	4.9	17	4.9	2.46	
-6	9.8	6	9.8	4.89	
-3	14.6	8	14.7	7.24	◄
28	19.5	38	19.4	9.49	
45	24.4	54	24.3	11.72	
68	29.3	77	29.1	13.90	◄
88	34.2	96	33.9	16.04	
102	39.1	110	38.7	18.15	
113	43.9	121	43.5	20.23	
77	41.5	86	41.2	19.24	
107	43.9	116	43.6	20.24	
119	48.8	128	48.4	22.28	
126	53.7	135	53.3	24.30	
131	58.6	139	58.1	26.28	
134	63.5	143	63.0	28.24	
137	68.3	146	67.9	30.17	
140	73.2	148	72.7	32.07	
142	78.1	150	77.6	33.95	
145	83.0	153	82.5	35.79	
147	87.9	155	87.4	37.62	

Test Results

Pressiometric modulus E:	1,529 psi
Unload Modulus	5,740 psi
Reload Modulus	4,810 psi
Ultimate pressure P_L:	170 psi
Yield pressure P_F:	77 psi
	psi
Ratio E / P_L:	9.01
Ratio P_L / P_F:	2.20

Calibration Sheet Reference

Remarks



ROCTEST TELEMAC

PRESSIO COMPANION V.15

TEXAM Pressuremeter Test

Project name: Imperial sustation
Borehole name: B-3
Test date: (mm/dd/yyyy) 06/12/2008
Test number: 3-7
Probe size: N

Use of a slotted casing: No
Test depth: 36.00 ft
Manometer height above ground: 1.64 ft
Poisson's coefficient: 0.33
Fluid density: 1.000

Raw Readings		Corrected Readings			
Pressure psi	Volume in³	Pressure psi	Volume in³	$\Delta R/R_0$ %	
0	0.0	16	0.0	0.00	
4	4.9	18	4.9	2.46	
5	9.8	18	9.7	4.87	
6	14.6	18	14.6	7.22	
8	19.5	20	19.5	9.52	
19	24.4	30	24.3	11.76	
34	29.3	45	29.2	13.96	◄
53	34.2	63	34.0	16.10	
74	39.1	84	38.8	18.20	
92	43.9	102	43.6	20.27	
30	41.5	41	41.4	19.31	
73	43.9	83	43.7	20.30	
103	48.8	113	48.5	22.32	
127	53.7	137	53.3	24.31	
146	58.6	157	58.1	26.28	
165	63.5	175	62.9	28.21	
184	68.3	194	67.7	30.12	
200	73.2	211	72.6	32.01	◄
214	78.1	224	77.4	33.87	
224	83.0	234	82.3	35.71	
239	87.9	248	87.1	37.52	
249	92.8	259	91.9	39.31	

Test Results

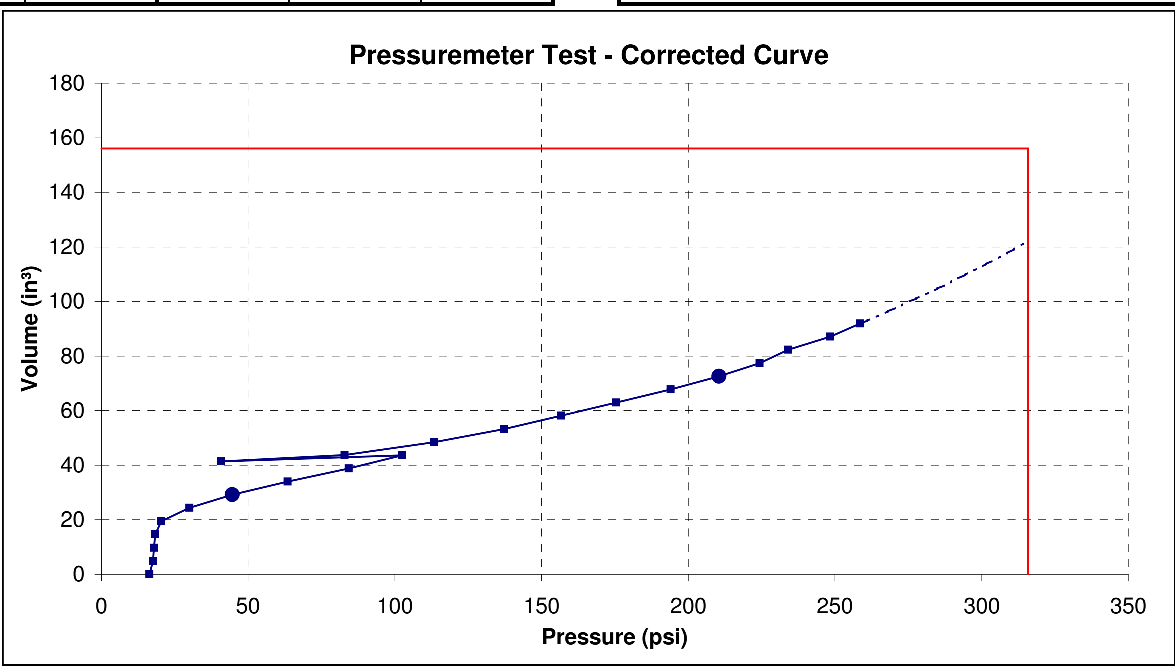
Pressiometric modulus E: 1,511 psi
Unload Modulus 10,260 psi
Reload Modulus 6,810 psi

Ultimate pressure P_L: 316 psi
Yield pressure P_F: 211 psi

Ratio E / P_L: 4.78
Ratio P_L / P_F: 1.50

Calibration Sheet Reference

Remarks



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PRESSIO COMPANION V.15

TEXAM Pressuremeter Test

Project name:	Imperial substation	Use of a slotted casing:	No
Borehole name:	B-3	Test depth:	46.00 ft
Test date: (mm/dd/yyyy)	06/12/2008	Manometer height above ground:	1.64 ft
Test number:	3-8	Poisson's coefficient:	0.33
Probe size:	N	Fluid density:	1.000

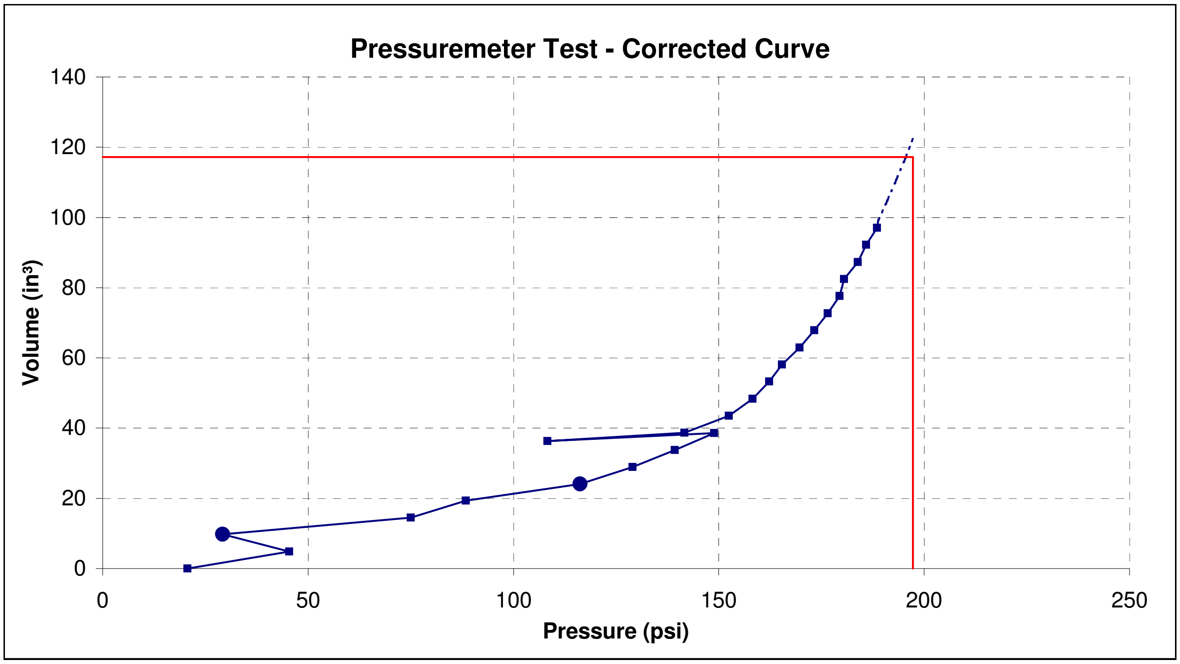
Raw Readings		Corrected Readings			
Pressure psi	Volume in³	Pressure psi	Volume in³	$\Delta R/R_0$ %	
0	0.0	21	0.0	0.00	
28	4.9	45	4.8	2.42	
12	9.8	29	9.7	4.86	◄
58	14.6	75	14.5	7.14	
72	19.5	88	19.3	9.43	
101	24.4	116	24.1	11.64	◄
114	29.3	129	28.9	13.84	
124	34.2	139	33.8	16.00	
134	39.1	149	38.6	18.12	
94	36.6	108	36.3	17.11	
127	39.1	142	38.6	18.13	
138	43.9	152	43.5	20.21	
144	48.8	158	48.4	22.26	
148	53.7	162	53.2	24.28	
151	58.6	165	58.1	26.27	
155	63.5	170	63.0	28.23	
159	68.3	173	67.8	30.16	
162	73.2	177	72.7	32.06	
165	78.1	179	77.6	33.93	
166	83.0	180	82.5	35.78	
170	87.9	184	87.3	37.60	
172	92.8	186	92.2	39.41	
174	97.6	188	97.1	41.18	

Test Results

Pressiometric modulus E:	1,848 psi
Unload Modulus	6,310 psi
Reload Modulus	5,130 psi
Ultimate pressure P_L:	197 psi
Yield pressure P_F:	116 psi
Ratio E / P_L:	9.37
Ratio P_L / P_F:	1.70

Calibration Sheet Reference

Remarks



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PRESSIO COMPANION V.15

TEXAM Pressuremeter Test

Project name:	Imperial substation	Use of a slotted casing:	No
Borehole name:	B-6	Test depth:	5.00 ft
Test date: (mm/dd/yyyy)	06/13/2008	Manometer height above ground:	1.64 ft
Test number:	6-1	Poisson's coefficient:	0.33
Probe size:	N	Fluid density:	1.000

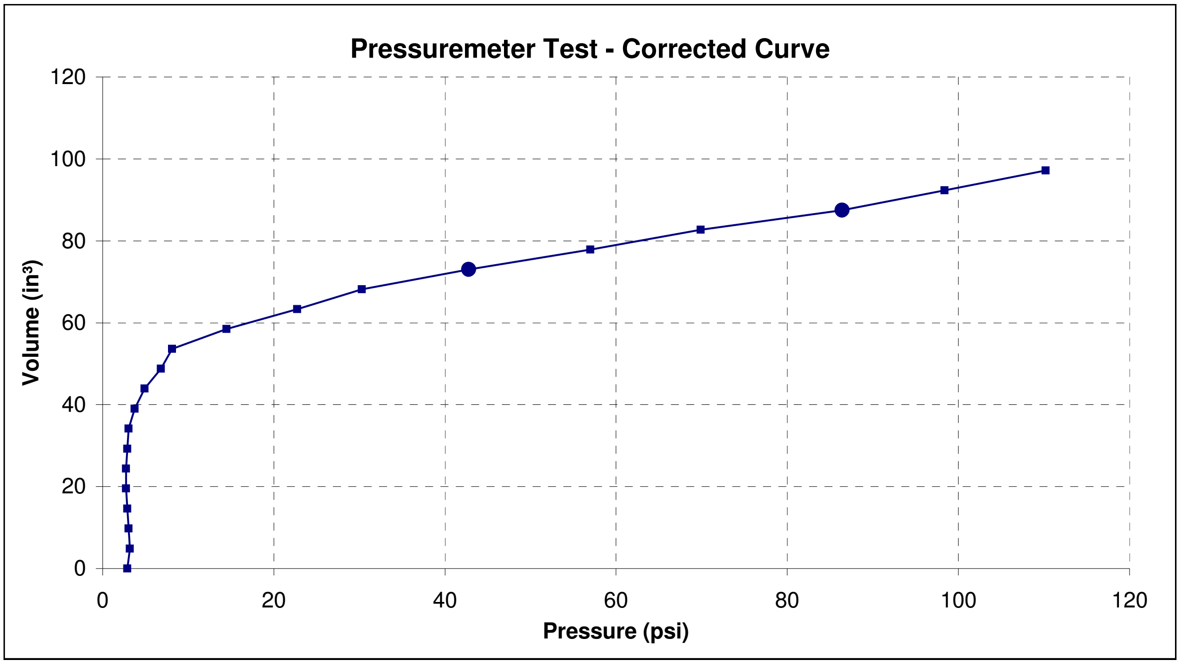
Raw Readings		Corrected Readings			
Pressure psi	Volume in³	Pressure psi	Volume in³	$\Delta R/R_0$ %	
0	0.0	3	0.0	0.00	
1	4.9	3	4.9	2.40	
3	9.8	3	9.8	4.74	
3	14.6	3	14.6	7.04	
4	19.5	3	19.5	9.28	
4	24.4	3	24.4	11.48	
6	29.3	3	29.3	13.64	
6	34.2	3	34.1	15.75	
7	39.1	4	39.0	17.83	
9	43.9	5	43.9	19.87	
11	48.8	7	48.8	21.88	
12	53.7	8	53.7	23.86	
19	58.6	14	58.5	25.79	
27	63.5	23	63.4	27.70	
35	68.3	30	68.2	29.57	
48	73.2	43	73.0	31.41	◄
62	78.1	57	77.9	33.23	
75	83.0	70	82.7	35.02	
92	87.9	86	87.5	36.78	◄
104	92.8	98	92.3	38.53	
116	97.6	110	97.2	40.26	

Test Results

Pressiometric modulus E:	1,451 psi
Unload Modulus	n.a.
Reload Modulus	n.a.
Ultimate pressure P_L:	n.a.
Yield pressure P_F:	86 psi
Ratio E / P_L:	n.a.
Ratio P_L / P_F:	n.a.

Calibration Sheet Reference

Remarks



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PRESSIO COMPANION V.15

TEXAM Pressuremeter Test

Project name:	Imperial substation	Use of a slotted casing:	No
Borehole name:	B-6	Test depth:	11.00 ft
Test date: (mm/dd/yyyy)	06/13/2008	Manometer height above ground:	1.64 ft
Test number:	6-2	Poisson's coefficient:	0.33
Probe size:	N	Fluid density:	1.000

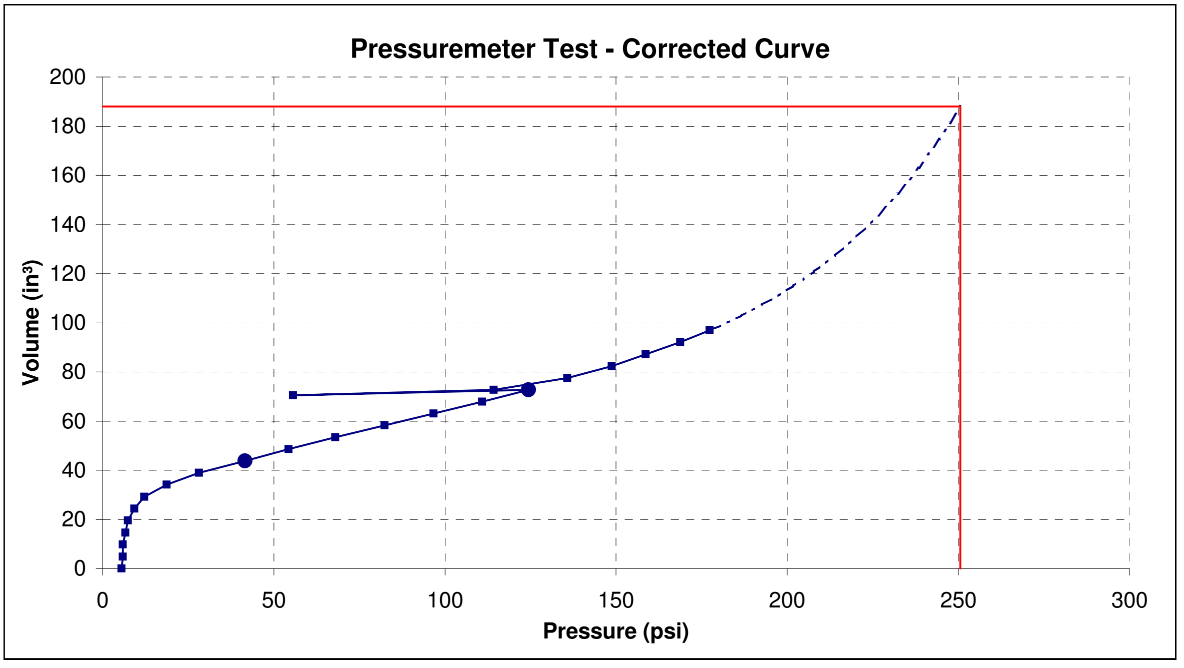
Raw Readings		Corrected Readings			
Pressure psi	Volume in³	Pressure psi	Volume in³	$\Delta R/R_0$ %	
0	0.0	5	0.0	0.00	
1	4.9	6	4.9	2.40	
3	9.8	6	9.8	4.74	
4	14.6	7	14.6	7.03	
6	19.5	7	19.5	9.28	
8	24.4	9	24.4	11.47	
12	29.3	12	29.2	13.63	
19	34.2	19	34.1	15.73	
29	39.1	28	38.9	17.80	
43	43.9	42	43.8	19.82	◄
56	48.8	54	48.6	21.81	
70	53.7	68	53.4	23.76	
84	58.6	82	58.2	25.69	
99	63.5	97	63.1	27.58	
113	68.3	111	67.9	29.45	
127	73.2	124	72.7	31.29	◄
58	70.8	56	70.6	30.47	
117	73.2	114	72.8	31.31	
139	78.1	136	77.5	33.11	
152	83.0	149	82.4	34.90	
162	87.9	159	87.2	36.68	
172	92.8	169	92.1	38.43	
181	97.6	177	96.9	40.16	

Test Results

Pressiometric modulus E:	1,208 psi
Unload Modulus	14,580 psi
Reload Modulus	12,190 psi
Ultimate pressure P_L:	251 psi
Yield pressure P_F:	124 psi
Ratio E / P_L:	4.82
Ratio P_L / P_F:	2.01

Calibration Sheet Reference

Remarks



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PRESSIO COMPANION V.15

Figure: C-10

TEXAM Pressuremeter Test

Project name:	Imperial substation	Use of a slotted casing:	No
Borehole name:	B-6	Test depth:	15.00 ft
Test date: (mm/dd/yyyy)	06/13/2008	Manometer height above ground:	1.64 ft
Test number:	6-3	Poisson's coefficient:	0.33
Probe size:	N	Fluid density:	1.000

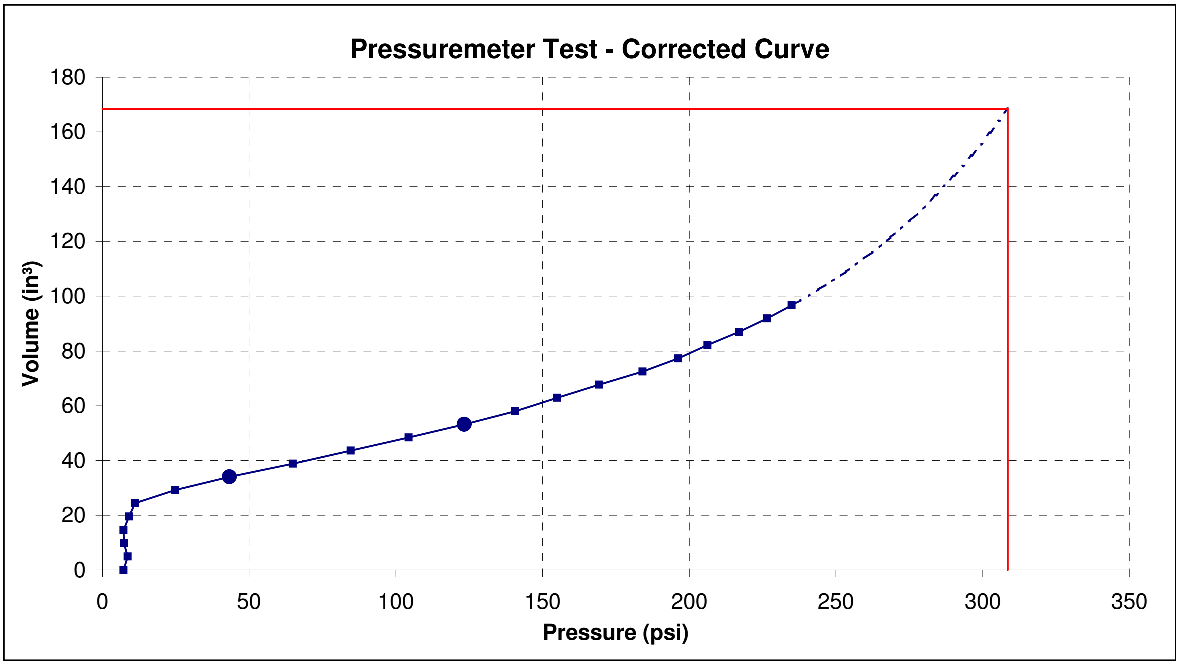
Raw Readings		Corrected Readings			
Pressure psi	Volume in³	Pressure psi	Volume in³	$\Delta R/R_0$ %	
0	0.0	7	0.0	0.00	
2	4.9	9	4.9	2.40	
3	9.8	7	9.8	4.74	
3	14.6	7	14.6	7.04	
6	19.5	9	19.5	9.28	
8	24.4	11	24.4	11.47	
23	29.3	25	29.2	13.61	
42	34.2	43	34.0	15.69	◄
64	39.1	65	38.8	17.73	
84	43.9	85	43.6	19.75	
104	48.8	104	48.4	21.72	
123	53.7	123	53.2	23.67	◄
141	58.6	141	58.0	25.59	
155	63.5	155	62.8	27.49	
170	68.3	169	67.7	29.36	
185	73.2	184	72.5	31.20	
197	78.1	196	77.3	33.02	
207	83.0	206	82.1	34.82	
218	87.9	217	87.0	36.59	
228	92.8	227	91.8	38.35	
236	97.6	235	96.7	40.08	

Test Results

Pressiometric modulus E:	1,598 psi
Unload Modulus	n.a.
Reload Modulus	n.a.
Ultimate pressure P_L:	309 psi
Yield pressure P_F:	123 psi
Ratio E / P_L:	5.18
Ratio P_L / P_F:	2.50

Calibration Sheet Reference

Remarks



TEXAM Pressuremeter Test

Project name:	Imperial substation	Use of a slotted casing:	No
Borehole name:	B-6	Test depth:	21.00 ft
Test date: (mm/dd/yyyy)	06/13/2008	Manometer height above ground:	1.64 ft
Test number:	6-4	Poisson's coefficient:	0.33
Probe size:	N	Fluid density:	1.000

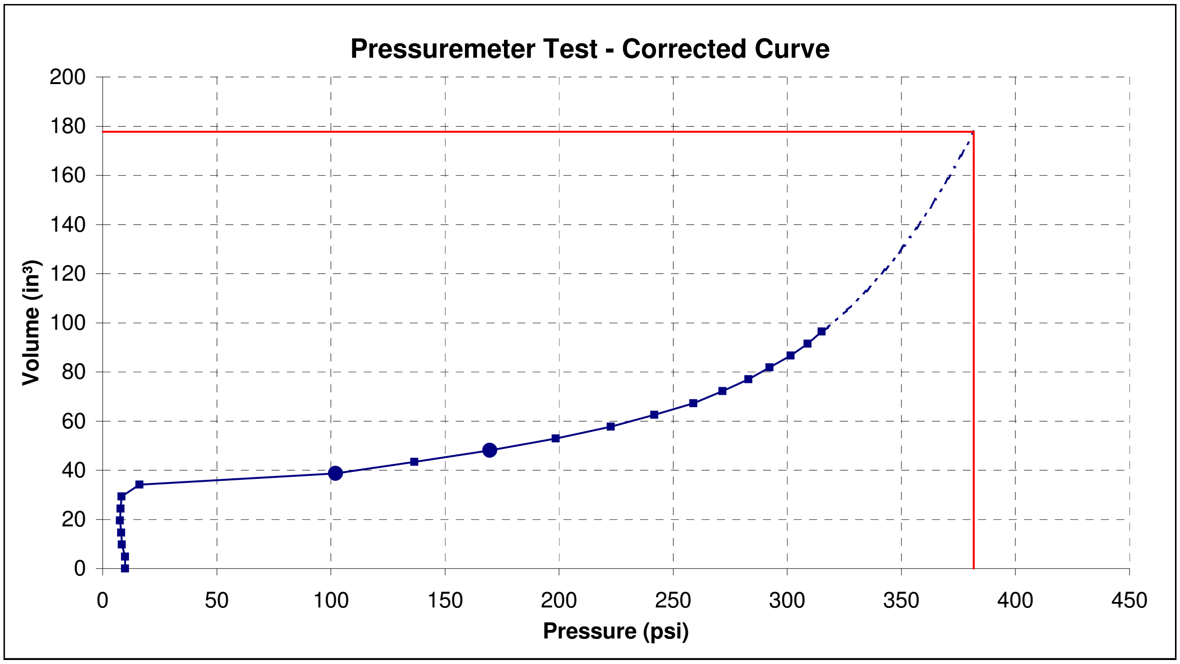
Raw Readings		Corrected Readings			
Pressure psi	Volume in³	Pressure psi	Volume in³	$\Delta R/R_0$ %	
0	0.0	10	0.0	0.00	
1	4.9	10	4.9	2.40	
1	9.8	8	9.8	4.74	
1	14.6	8	14.6	7.04	
2	19.5	8	19.5	9.28	
2	24.4	8	24.4	11.48	
4	29.3	8	29.3	13.64	
12	34.2	16	34.1	15.74	
99	39.1	102	38.7	17.67	◄
133	43.9	137	43.4	19.66	
167	48.8	170	48.1	21.62	◄
196	53.7	199	52.9	23.55	
220	58.6	223	57.7	25.47	
239	63.5	242	62.5	27.36	
257	68.3	259	67.3	29.22	
270	73.2	272	72.1	31.07	
281	78.1	283	77.0	32.89	
291	83.0	292	81.8	34.69	
300	87.9	301	86.6	36.47	
308	92.8	309	91.5	38.23	
314	97.6	315	96.4	39.97	

Test Results

Pressiometric modulus E:	2,727 psi
Unload Modulus	n.a.
Reload Modulus	n.a.
Ultimate pressure P_L:	382 psi
Yield pressure P_F:	170 psi
Ratio E / P_L:	7.15
Ratio P_L / P_F:	2.25

Calibration Sheet Reference

Remarks



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PRESSIO COMPANION V.15

TEXAM Pressuremeter Test

Project name:	Imperial substation	Use of a slotted casing:	No
Borehole name:	B-6	Test depth:	31.00 ft
Test date: (mm/dd/yyyy)	06/13/2008	Manometer height above ground:	1.64 ft
Test number:	6-5	Poisson's coefficient:	0.33
Probe size:	N	Fluid density:	1.000

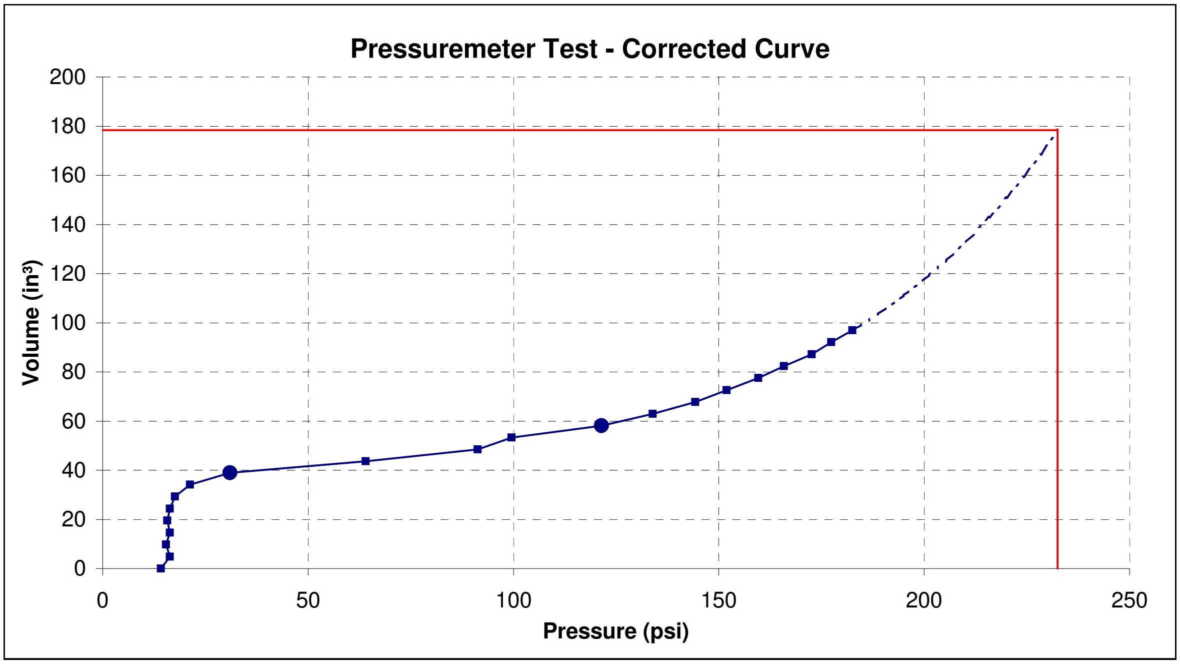
Raw Readings		Corrected Readings			
Pressure psi	Volume in³	Pressure psi	Volume in³	$\Delta R/R_0$ %	
0	0.0	14	0.0	0.00	
3	4.9	16	4.9	2.40	
4	9.8	15	9.7	4.74	
5	14.6	16	14.6	7.03	
6	19.5	16	19.5	9.28	
7	24.4	16	24.4	11.48	
9	29.3	18	29.3	13.63	
13	34.2	21	34.1	15.74	
23	39.1	31	39.0	17.81	◄
57	43.9	64	43.7	19.79	
84	48.8	91	48.5	21.76	
93	53.7	100	53.3	23.72	
115	58.6	121	58.1	25.64	◄
127	63.5	134	62.9	27.54	
138	68.3	144	67.8	29.41	
146	73.2	152	72.6	31.26	
154	78.1	160	77.5	33.09	
160	83.0	166	82.3	34.89	
167	87.9	173	87.2	36.67	
172	92.8	177	92.1	38.43	
177	97.6	183	96.9	40.17	

Test Results

Pressiometric modulus E:	1,873 psi
Unload Modulus	n.a.
Reload Modulus	n.a.
Ultimate pressure P_L:	232 psi
Yield pressure P_F:	121 psi
Ratio E / P_L:	8.06
Ratio P_L / P_F:	1.91

Calibration Sheet Reference

Remarks



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PRESSIO COMPANION V.15

TEXAM Pressuremeter Test

Project name:	Imperial substation	Use of a slotted casing:	No
Borehole name:	B-7	Test depth:	4.50 ft
Test date: (mm/dd/yyyy)	06/12/2008	Manometer height above ground:	1.64 ft
Test number:	7-1	Poisson's coefficient:	0.33
Probe size:	N	Fluid density:	1.000

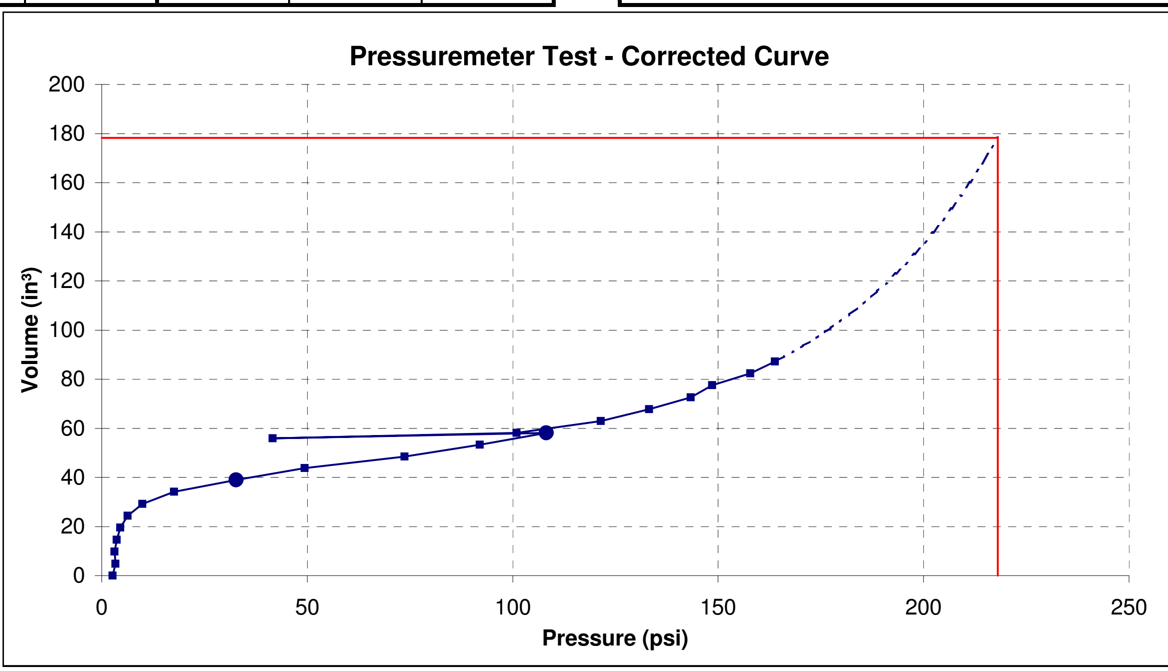
Raw Readings		Corrected Readings			
Pressure psi	Volume in³	Pressure psi	Volume in³	$\Delta R/R_0$ %	
0	0.0	3	0.0	0.00	
1	4.9	3	4.9	2.40	
3	9.8	3	9.8	4.74	
4	14.6	4	14.6	7.03	
6	19.5	5	19.5	9.28	
8	24.4	6	24.4	11.47	
13	29.3	10	29.2	13.62	
21	34.2	18	34.1	15.73	
36	39.1	33	38.9	17.78	◄
53	43.9	49	43.7	19.80	
78	48.8	74	48.5	21.77	
96	53.7	92	53.3	23.72	
113	58.6	108	58.1	25.64	◄
46	56.1	42	56.0	24.78	
106	58.6	101	58.2	25.65	
126	63.5	121	62.9	27.54	
138	68.3	133	67.8	29.41	
149	73.2	143	72.6	31.26	
154	78.1	149	77.5	33.09	
164	83.0	158	82.3	34.89	
170	87.9	164	87.2	36.67	

Test Results

Pressiometric modulus E:	1,558 psi
Unload Modulus	12,880 psi
Reload Modulus	11,320 psi
Ultimate pressure P_L:	218 psi
Yield pressure P_F:	108 psi
Ratio E / P_L:	7.15
Ratio P_L / P_F:	2.01

Calibration Sheet Reference

Remarks



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PRESSIO COMPANION V.15

Figure: C-14

TEXAM Pressuremeter Test

Project name:	Imperial substation	Use of a slotted casing:	No
Borehole name:	B-7	Test depth:	11.00 ft
Test date: (mm/dd/yyyy)	06/12/2008	Manometer height above ground:	1.64 ft
Test number:	7-2	Poisson's coefficient:	0.33
Probe size:	N	Fluid density:	1.000

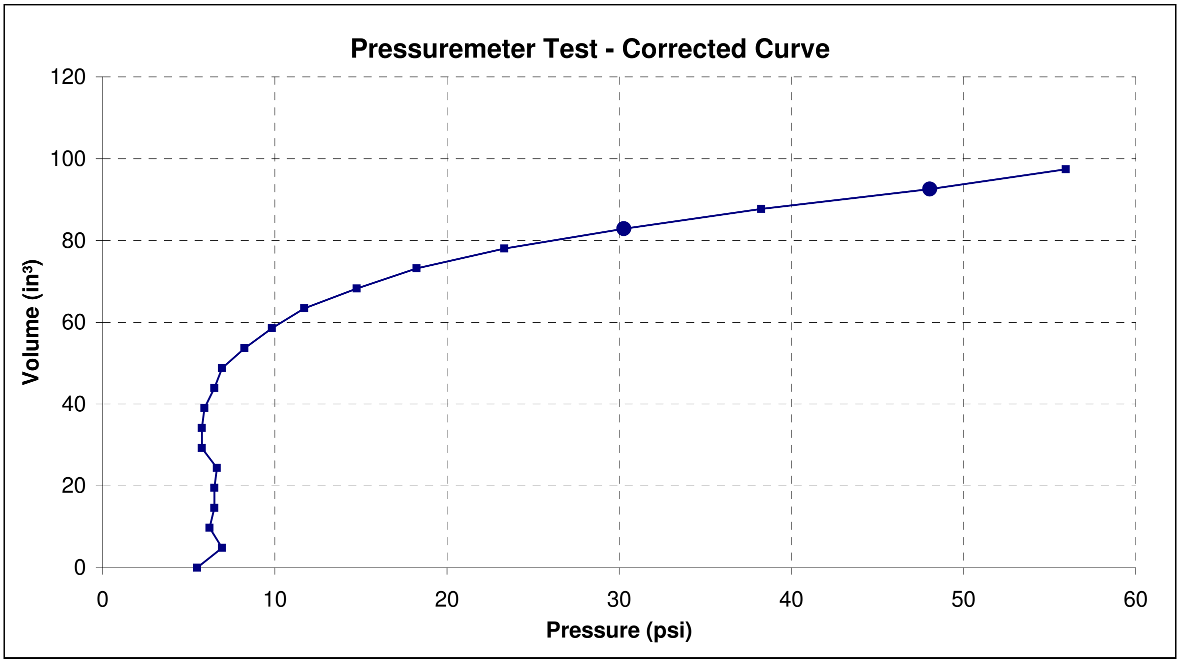
Raw Readings		Corrected Readings			
Pressure psi	Volume in³	Pressure psi	Volume in³	$\Delta R/R_0$ %	
0	0.0	5	0.0	0.00	
2	4.9	7	4.9	2.40	
3	9.8	6	9.8	4.74	
4	14.6	6	14.6	7.03	
5	19.5	6	19.5	9.28	
6	24.4	7	24.4	11.48	
6	29.3	6	29.3	13.64	
6	34.2	6	34.1	15.75	
7	39.1	6	39.0	17.83	
8	43.9	6	43.9	19.88	
8	48.8	7	48.8	21.89	
10	53.7	8	53.7	23.86	
12	58.6	10	58.5	25.80	
14	63.5	12	63.4	27.72	
17	68.3	15	68.3	29.60	
21	73.2	18	73.1	31.46	
26	78.1	23	78.0	33.28	
33	83.0	30	82.9	35.08	◄
41	87.9	38	87.7	36.86	
51	92.8	48	92.5	38.61	◄
59	97.6	56	97.4	40.34	

Test Results

Pressiometric modulus E:	918 psi
Unload Modulus	n.a.
Reload Modulus	n.a.
Ultimate pressure P_L:	n.a.
Yield pressure P_F:	48 psi
Ratio E / P_L:	n.a.
Ratio P_L / P_F:	n.a.

Calibration Sheet Reference

Remarks



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PRESSIO COMPANION V.15

Figure: C-15

TEXAM Pressuremeter Test

Project name:	Imperial substation	Use of a slotted casing:	No
Borehole name:	B-7	Test depth:	16.00 ft
Test date: (mm/dd/yyyy)	06/12/2008	Manometer height above ground:	1.64 ft
Test number:	7-3	Poisson's coefficient:	0.33
Probe size:	N	Fluid density:	1.000

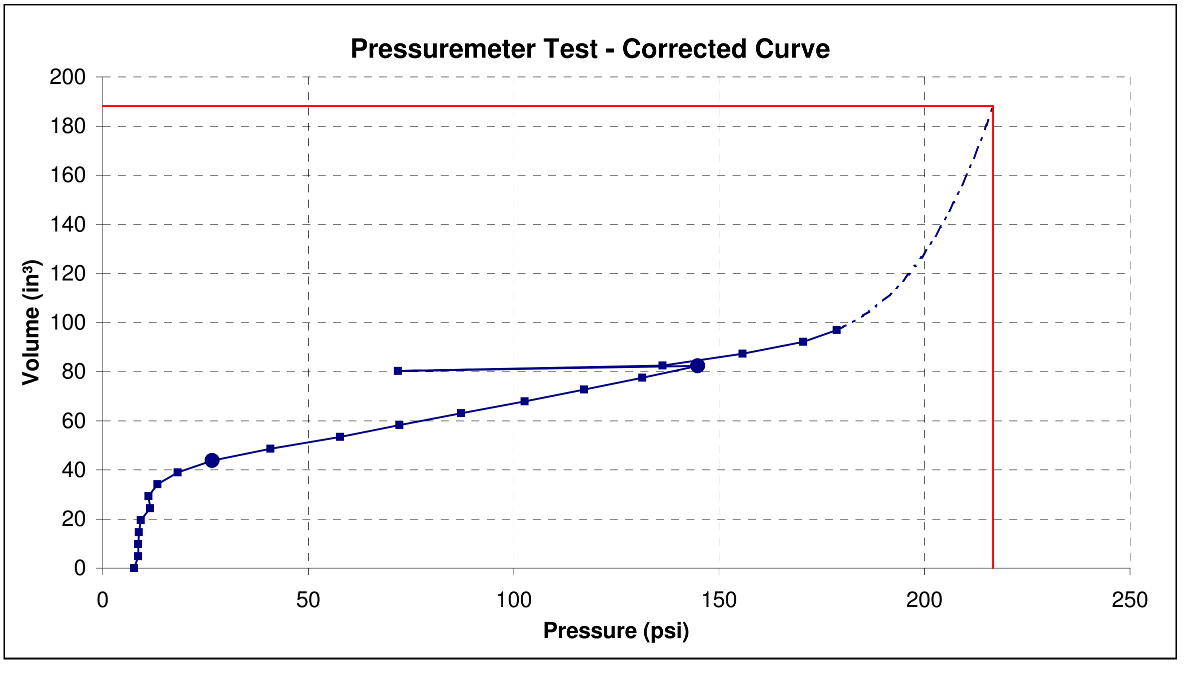
Raw Readings		Corrected Readings		
Pressure psi	Volume in³	Pressure psi	Volume in³	$\Delta R/R_0$ %
0	0.0	8	0.0	0.00
2	4.9	9	4.9	2.40
3	9.8	9	9.7	4.74
4	14.6	9	14.6	7.03
6	19.5	9	19.5	9.28
8	24.4	12	24.4	11.47
9	29.3	11	29.3	13.63
12	34.2	13	34.1	15.74
17	39.1	18	39.0	17.82
26	43.9	27	43.8	19.85
40	48.8	41	48.7	21.83
57	53.7	58	53.5	23.78
72	58.6	72	58.3	25.71
87	63.5	87	63.1	27.60
103	68.3	103	67.9	29.47
117	73.2	117	72.7	31.31
132	78.1	131	77.6	33.12
146	83.0	145	82.4	34.91
73	80.6	72	80.3	34.12
137	83.0	136	82.4	34.93
157	87.9	156	87.2	36.69
171	92.8	170	92.1	38.43
180	97.6	179	96.9	40.16

Test Results

Pressiometric modulus E:	1,334 psi
Unload Modulus	16,490 psi
Reload Modulus	14,320 psi
Ultimate pressure P_L:	217 psi
Yield pressure P_F:	145 psi
Ratio E / P_L:	6.15
Ratio P_L / P_F:	1.50

Calibration Sheet Reference

Remarks



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PRESSIO COMPANION V.15

TEXAM Pressuremeter Test

Project name:	Imperial substation	Use of a slotted casing:	No
Borehole name:	B-7	Test depth:	21.00 ft
Test date: (mm/dd/yyyy)	06/13/2008	Manometer height above ground:	1.64 ft
Test number:	7-4	Poisson's coefficient:	0.33
Probe size:	N	Fluid density:	1.000

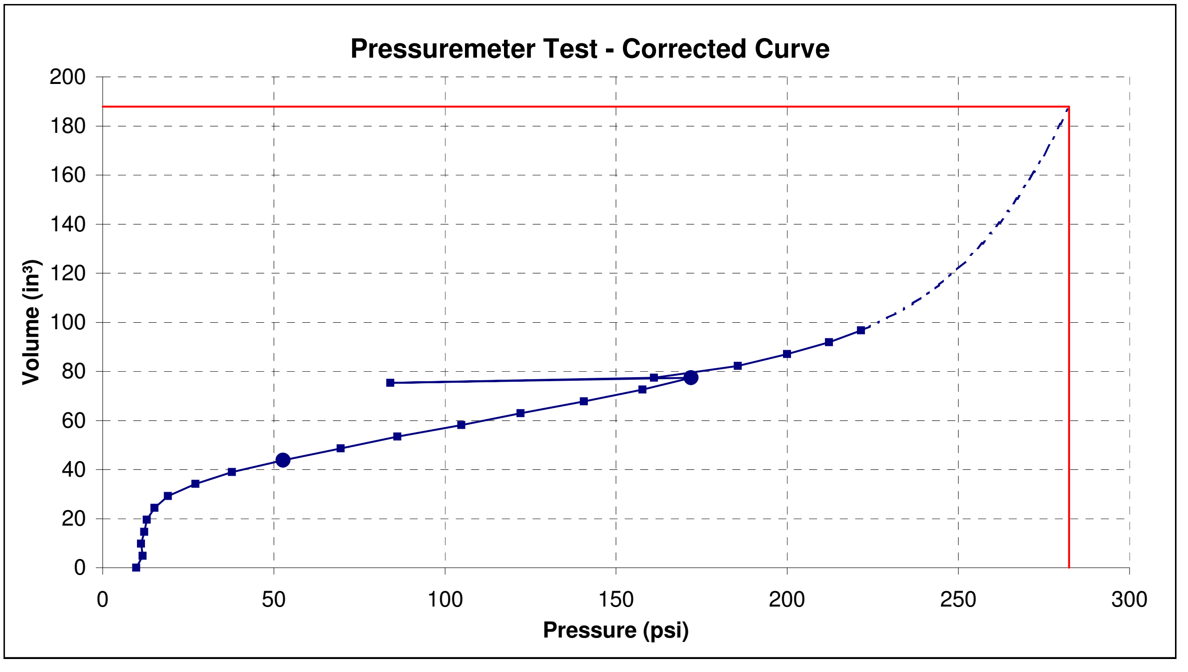
Raw Readings		Corrected Readings			
Pressure psi	Volume in³	Pressure psi	Volume in³	$\Delta R/R_0$ %	
0	0.0	10	0.0	0.00	
3	4.9	12	4.9	2.40	
4	9.8	11	9.7	4.74	
6	14.6	12	14.6	7.03	
7	19.5	13	19.5	9.27	
10	24.4	15	24.4	11.47	
15	29.3	19	29.2	13.62	
23	34.2	27	34.1	15.72	
34	39.1	38	38.9	17.79	
50	43.9	53	43.7	19.80	◄
67	48.8	70	48.5	21.79	
83	53.7	86	53.4	23.74	
102	58.6	105	58.2	25.66	
120	63.5	122	63.0	27.55	
139	68.3	141	67.8	29.41	
156	73.2	158	72.6	31.25	
170	78.1	172	77.4	33.06	◄
82	75.7	84	75.3	32.28	
160	78.1	161	77.5	33.08	
184	83.0	186	82.2	34.86	
199	87.9	200	87.1	36.62	
211	92.8	212	91.9	38.37	
220	97.6	222	96.7	40.10	

Test Results

Pressiometric modulus E:	1,516 psi
Unload Modulus	19,870 psi
Reload Modulus	17,050 psi
Ultimate pressure P_L:	282 psi
Yield pressure P_F:	172 psi
Ratio E / P_L:	5.37
Ratio P_L / P_F:	1.64

Calibration Sheet Reference

Remarks



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PRESSIO COMPANION V.15

TEXAM Pressuremeter Test

Project name:	Imperial substation	Use of a slotted casing:	No
Borehole name:	B-7	Test depth:	31.00 ft
Test date: (mm/dd/yyyy)	06/13/2008	Manometer height above ground:	1.64 ft
Test number:	7-5	Poisson's coefficient:	0.33
Probe size:	N	Fluid density:	1.000

Raw Readings		Corrected Readings			
Pressure psi	Volume in³	Pressure psi	Volume in³	$\Delta R/R_0$ %	
0	0.0	14	0.0	0.00	
3	4.9	16	4.9	2.40	
4	9.8	15	9.7	4.74	
5	14.6	16	14.6	7.03	
6	19.5	16	19.5	9.28	
10	24.4	20	24.4	11.47	
20	29.3	29	29.2	13.61	
46	34.2	54	34.0	15.68	◄
103	39.1	111	38.6	17.67	
163	43.9	171	43.3	19.61	◄
208	48.8	215	48.0	21.55	
244	53.7	251	52.7	23.47	
273	58.6	280	57.5	25.38	
293	63.5	300	62.3	27.27	
309	68.3	315	67.1	29.14	
324	73.2	330	71.9	30.98	
334	78.1	339	76.7	32.81	
343	83.0	349	81.6	34.61	
352	87.9	358	86.4	36.39	

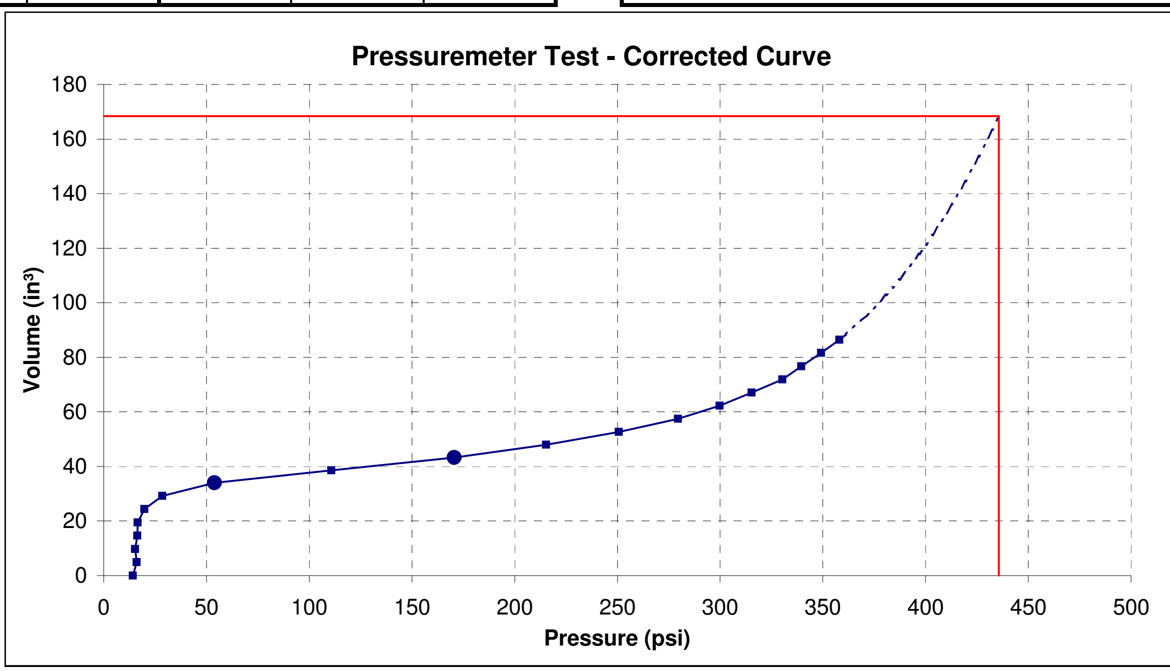
Test Results

Pressiometric modulus E:	4,653 psi
Unload Modulus	n.a. psi
Reload Modulus	n.a. psi
Ultimate pressure P_L:	436 psi
Yield pressure P_F:	171 psi
Ratio E / P_L:	10.68
Ratio P_L / P_F:	2.55

Calibration Sheet Reference

Remarks

Coarse sand in drill cuttings



ROCTEST TELEMAC

PRESSIO COMPANION V.15

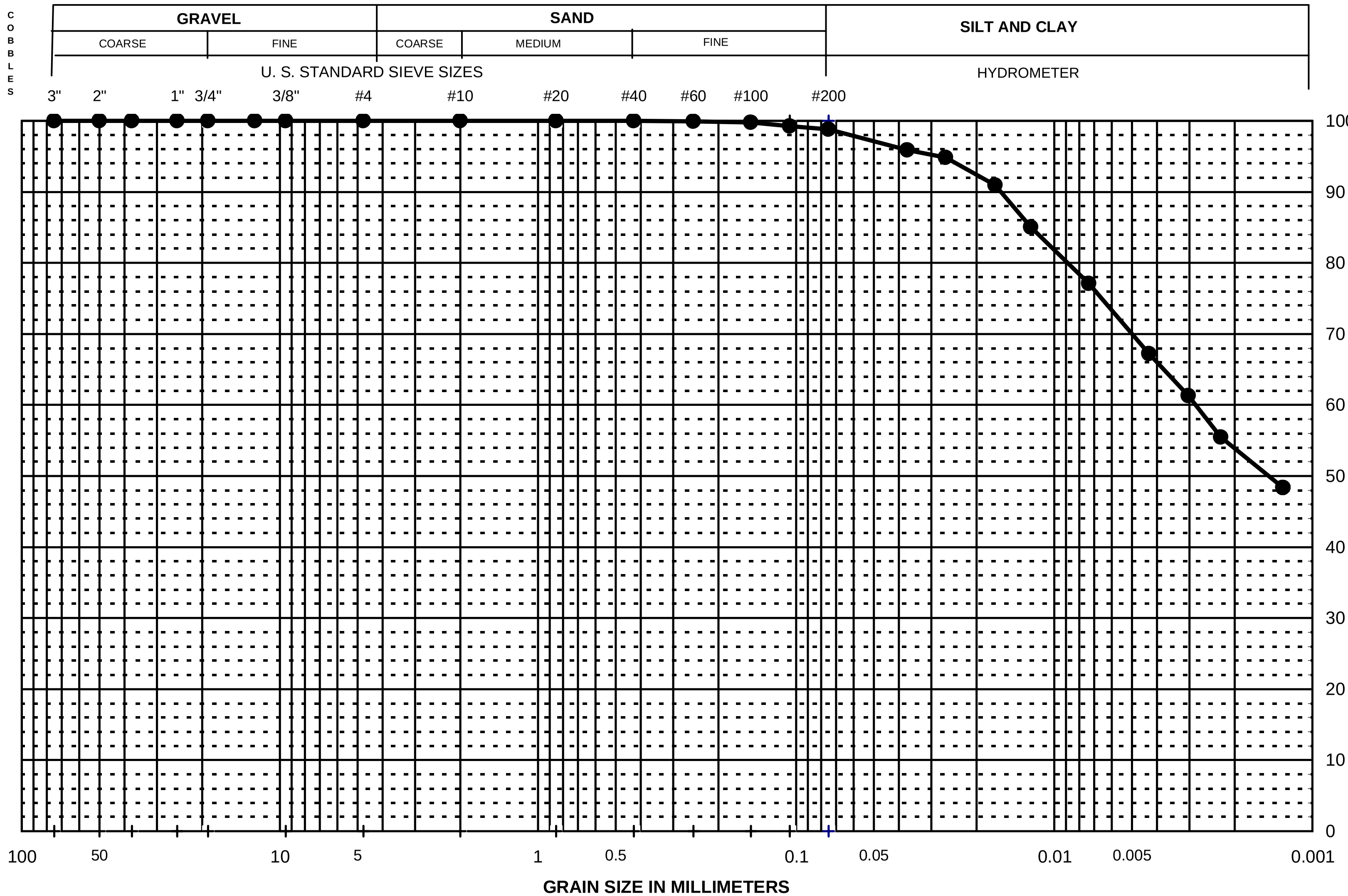
The materials observed in the borings were visually classified and evaluated with respect to strength, density and consistency, and moisture content. The strength of the soil was evaluated by considering the density and moisture content of the samples, the penetration resistance of the sampler, and the results of direct shear and triaxial compression tests. A laboratory compaction test was performed on a sample of near surface soil to evaluate the moisture density relationship. Resistivity, sulfate content, pH, and chloride content tests were performed to evaluate the potential corrosivity of the soils. An Expansion Index test was performed to evaluate shrink/swell potential of soil below the proposed mat foundations. Testing was performed in general accordance with applicable ASTM standards.

The results of the grain size analyses, Atterberg Limits, moisture content, and dry density tests are shown with the penetration resistance of the sampler, where applicable, at the corresponding sample location on the logs, Figures B-2 through B-9.

Graphical laboratory test results are presented on the following figures in this appendix:

- Sieve analysis (Figure D-1 through D-8);
- Laboratory compaction (Figure D-9);
- Atterberg limits tests (Figures D-10 and D-11);
- Direct shear tests (Figures D-12 through D-16);
- Unconsolidated undrained triaxial compression tests (Figures D-17 through D-20);
- Corrosion testing (Figures D-21 through D-25);
- Expansion Index testing (Figure D-26); and
- Wash analysis (Figure D-27).

UNIFIED SOIL CLASSIFICATION



Sieve No.	Dia. mm	% Finer
3"	75.0	100.0
2"	50.0	100.0
1.5"	37.5	100.0
1"	25.0	100.0
3/4"	19.00	100.0
1/2"	12.50	100.0
3/8"	9.50	100.0
#4	4.75	100.0
#10	2.00	100.0
#20	0.850	100.0
#40	0.425	100.0
#60	0.250	99.9
#100	0.150	99.8
#140	0.106	99.2
#200	0.075	98.8
Hydrometer Analysis	0.0370	95.9
	0.0263	94.9
	0.0170	90.9
	0.0123	85.0
	0.0074	77.1
	0.0043	67.2
	0.0030	61.3
	0.0023	55.5
	0.0013	48.4
	0.0013	48.4
% Cobbles		
% Gravel		0.0
% Sand		1.2
% Fines		98.8
D_{60}		
D_{30}		
D_{10}		
C_u		
C_c		

Exploration	Sample No.	Depth (ft)	SYMBOL	Wn (%)	LL	PI	% 5 µm	Description and Classification
B-4	10	45.0	●	29.8	49	33	70	**Brown CLAY (CL)**

PROJECT NAME: **Imperial Valley Substation**

PROJECT NUMBER: **27668011**

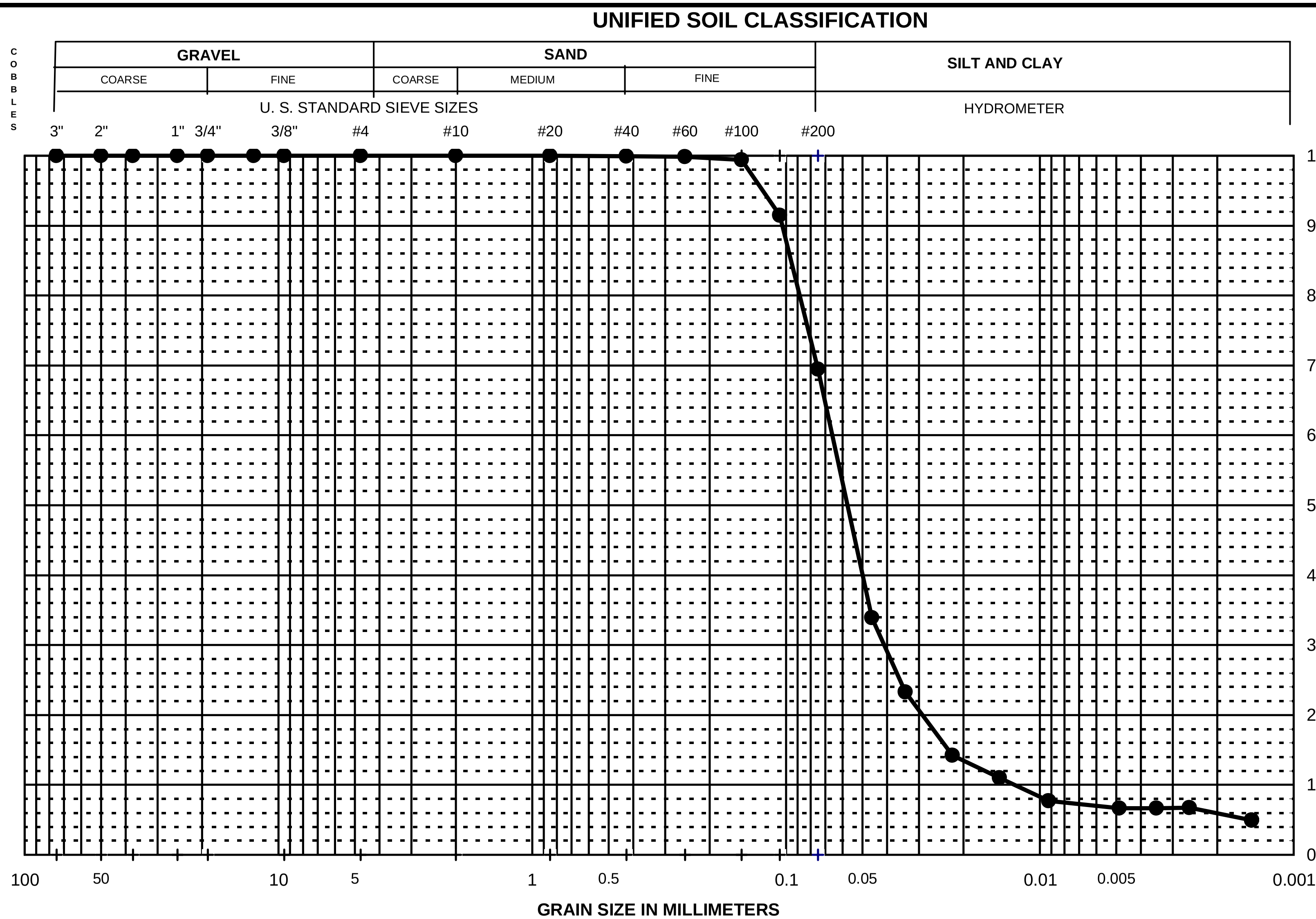
PARTICLE-SIZE DISTRIBUTION CURVES

Figure: D-1

(SNA) sieve only (04/2000)

Fig D1 Hydrometer IVS B04045

URS



Sieve No.	Dia. mm	% Finer
3"	75.0	100.0
2"	50.0	100.0
1.5"	37.5	100.0
1"	25.0	100.0
3/4"	19.00	100.0
1/2"	12.50	100.0
3/8"	9.50	100.0
#4	4.75	100.0
#10	2.00	100.0
#20	0.850	100.0
#40	0.425	99.9
#60	0.250	99.9
#100	0.150	99.4
#140	0.106	91.4
#200	0.075	69.5
Hydrometer Analysis	0.0460	33.9
	0.0338	23.2
	0.0221	14.2
	0.0144	11.0
	0.0092	7.7
	0.0049	6.6
	0.0035	6.6
	0.0026	6.7
	0.0015	4.9
	0.0015	4.9

% Cobbles	
% Gravel	0.0
% Sand	30.5
% Fines	69.5
D_{60}	
D_{30}	
D_{10}	
C_u	
C_c	

Exploration	Sample No.	Depth (ft)	SYMBOL	Wn (%)	LL	PI	% 5 μm	Description and Classification
B-5	9	40.0	•	27.4	26	9	6	**Brown Sandy CLAY (CL)**

PROJECT NAME: **Imperial Valley Substation**

PROJECT NUMBER: **27668011**

PARTICLE-SIZE DISTRIBUTION CURVES

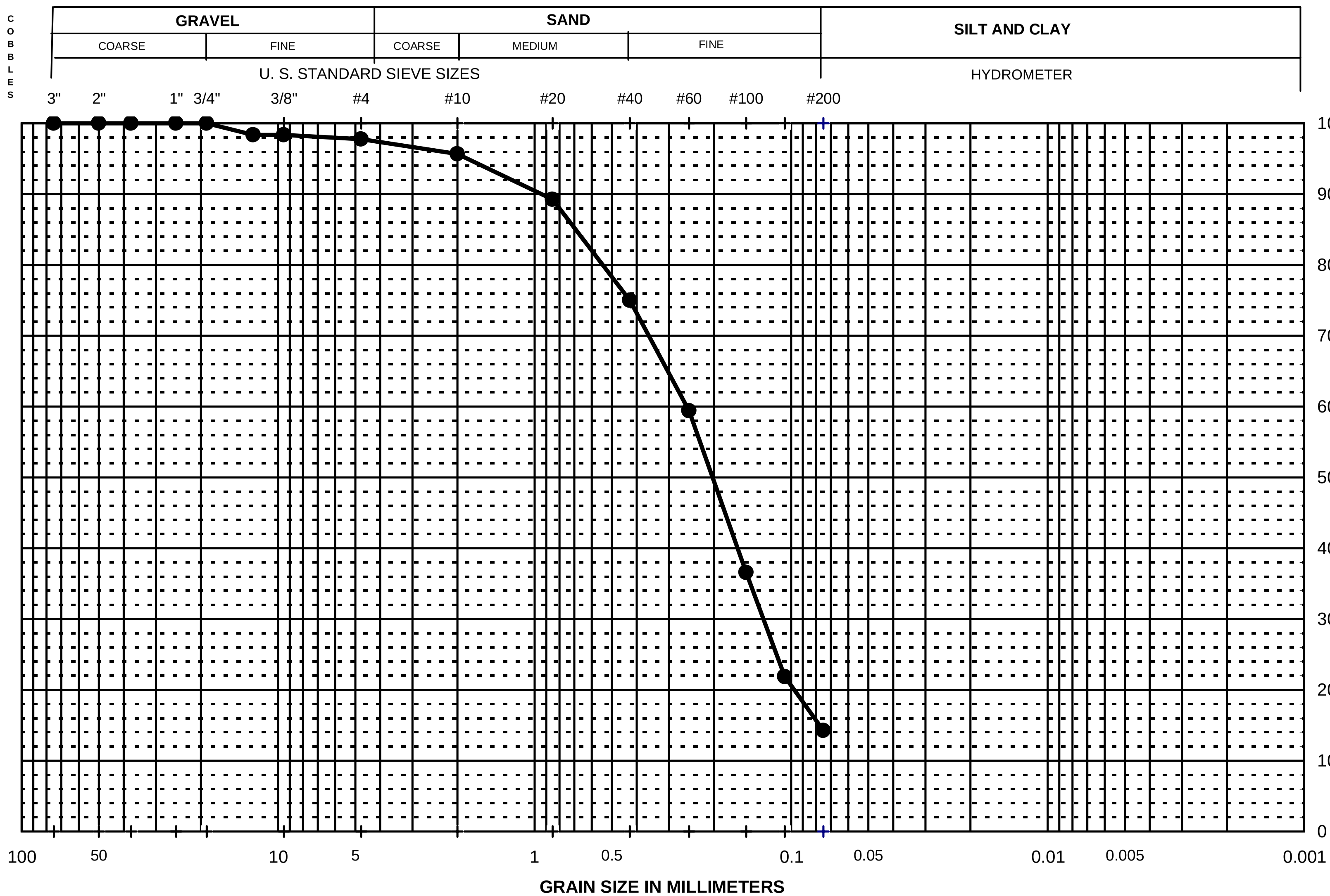
Figure: D-2

URS

(SNA) sieve only (04/2000)

Fig D2 Hydrometer IVS B05040

UNIFIED SOIL CLASSIFICATION



Sieve No.	Dia. mm	% Finer
3"	75.0	100.0
2"	50.0	100.0
1.5"	37.5	100.0
1"	25.0	100.0
3/4"	19.00	100.0
1/2"	12.50	98.4
3/8"	9.50	98.4
#4	4.75	97.8
#10	2.00	95.7
#20	0.850	89.3
#40	0.425	75.0
#60	0.250	59.4
#100	0.150	36.6
#140	0.106	21.9
#200	0.075	14.3
Hydrometer Analysis		

% Cobbles	
% Gravel	2.2
% Sand	83.5
% Fines	14.3
D_{60}	
D_{30}	
D_{10}	
C_u	
C_c	

Exploration	Sample No.	Depth (ft)	SYMBOL	Wn (%)	LL	PI	% Clay	Description and Classification
B-6	1	2.0	●					**Light Brown SAND with Silt (SP-SM)**

PROJECT NAME: **Imperial Valley Substation**

PROJECT NUMBER: **27668011**

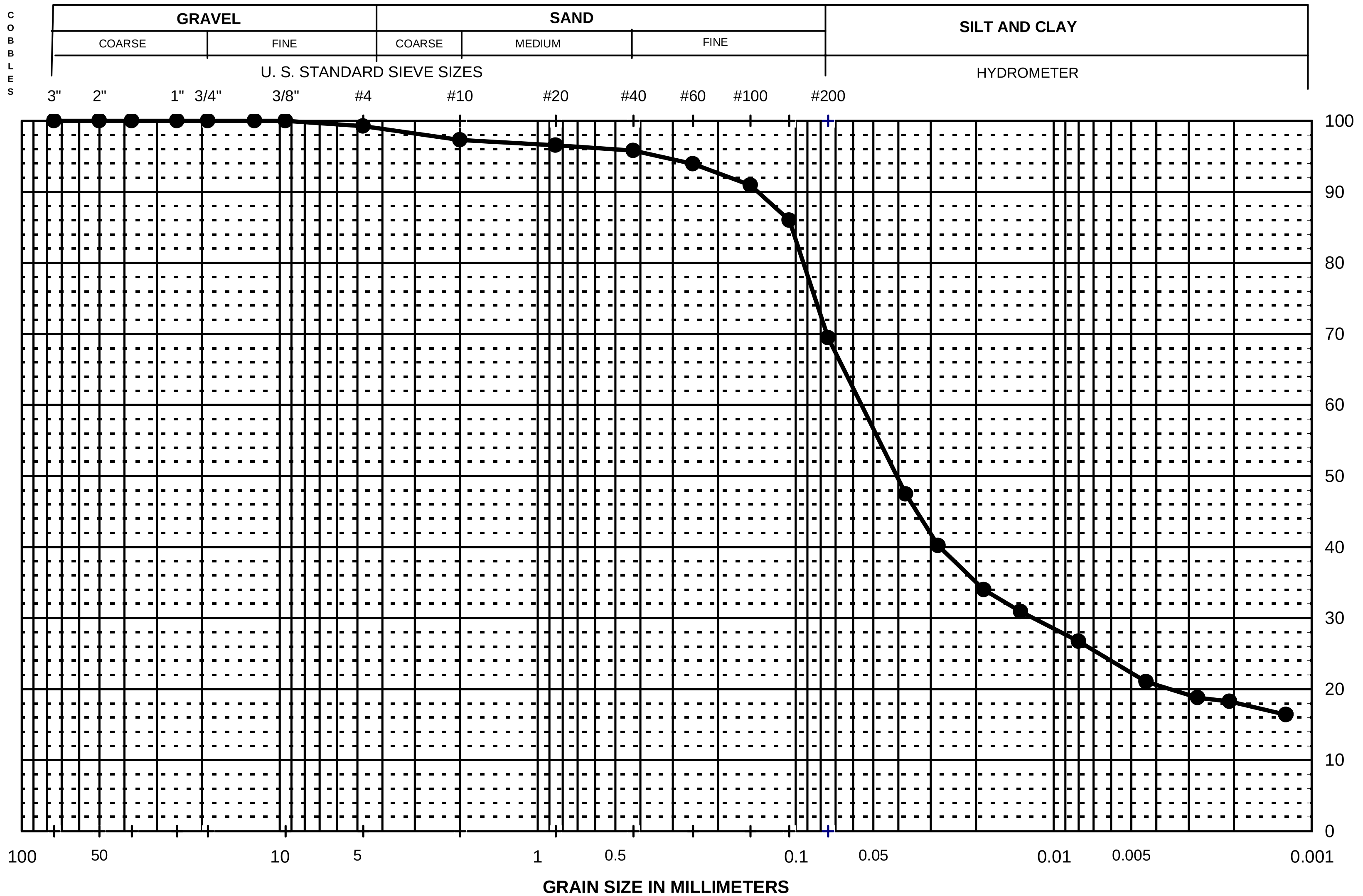
PARTICLE-SIZE DISTRIBUTION CURVES

Figure: D-3

URS

Fig D3 Sieve IVS B06002

UNIFIED SOIL CLASSIFICATION



Sieve No.	Dia. mm	% Finer
3"	75.0	100.0
2"	50.0	100.0
1.5"	37.5	100.0
1"	25.0	100.0
3/4"	19.00	100.0
1/2"	12.50	100.0
3/8"	9.50	100.0
#4	4.75	99.3
#10	2.00	97.3
#20	0.850	96.6
#40	0.425	95.8
#60	0.250	93.9
#100	0.150	91.0
#140	0.106	86.0
#200	0.075	69.4
Hydrometer Analysis	0.0374	47.5
	0.0281	40.2
	0.0186	34.0
	0.0134	30.9
	0.0080	26.7
	0.0044	21.0
	0.0028	18.8
	0.0021	18.2
	0.0013	16.4
	0.0013	16.4

% Cobbles	
% Gravel	0.7
% Sand	29.9
% Fines	69.4
D_{60}	
D_{30}	
D_{10}	
C_u	
C_c	

Exploration	Sample No.	Depth (ft)	SYMBOL	Wn (%)	LL	PI	% Clay	Description and Classification
B-6	5	20.0	●				18	**Light Brown Sandy CLAY (CL)**

PROJECT NAME: **Imperial Valley Substation**

PROJECT NUMBER: **27668011**

PARTICLE-SIZE DISTRIBUTION CURVES

Figure: D-4

(SNA) sieve only (04/2000)

Fig D4 Hydrometer IVS B06020

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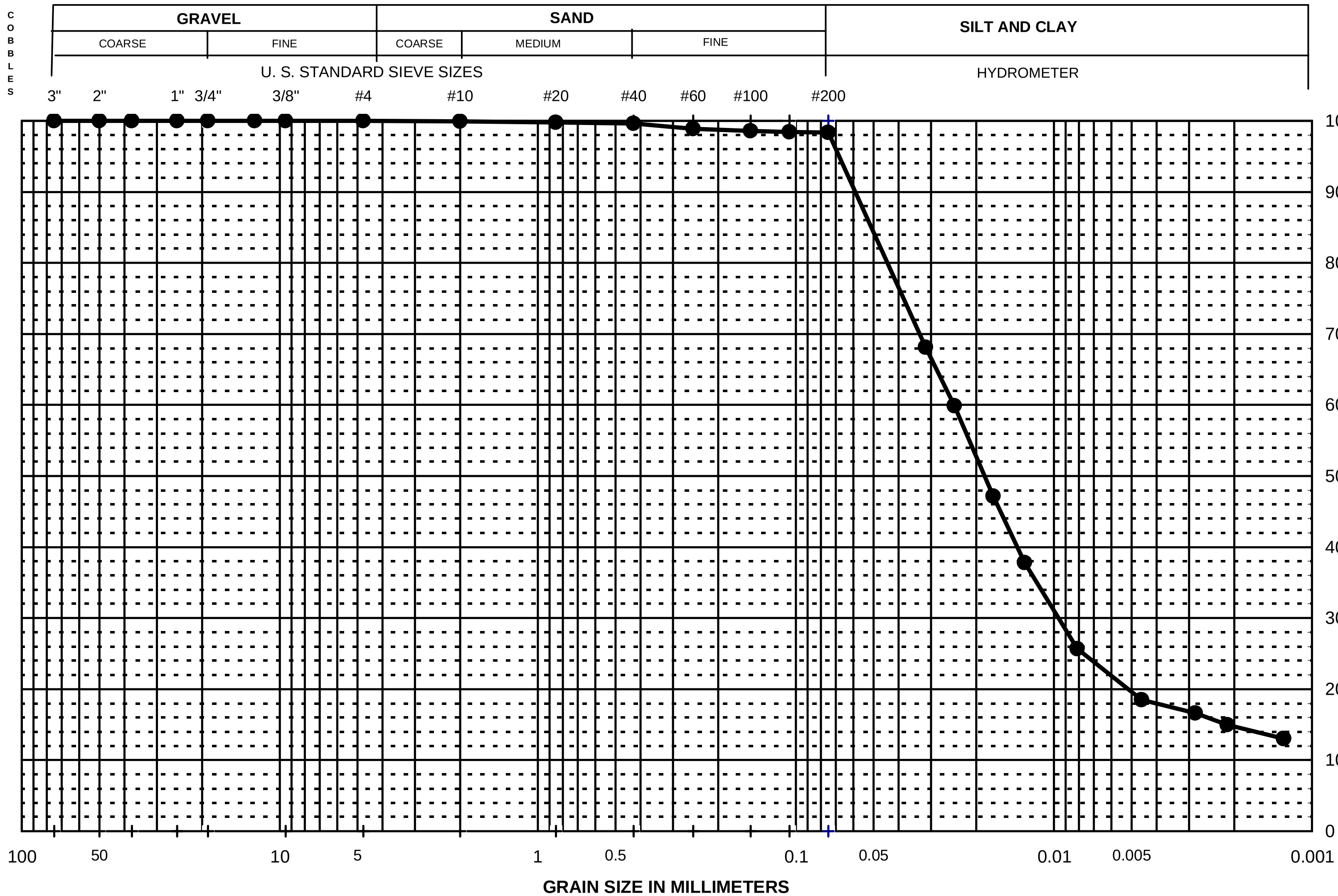
UNIFIED SOIL CLASSIFICATION



Sieve No.	Dia. mm	% Finer
3"	75.0	100.0
2"	50.0	100.0
1.5"	37.5	100.0
1"	25.0	100.0
3/4"	19.00	100.0
1/2"	12.50	100.0
3/8"	9.50	100.0
#4	4.75	100.0
#10	2.00	99.9
#20	0.850	99.8
#40	0.425	99.6
#60	0.250	98.9
#100	0.150	98.6
#140	0.106	98.4
#200	0.075	98.3
Hydrometer Analysis	0.0314	68.1
	0.0243	59.9
	0.0172	47.2
	0.0130	37.8
	0.0081	25.7
	0.0046	18.5
	0.0028	16.6
	0.0021	15.0
	0.0013	13.0
	0.0013	13.0

% Cobbles	
% Gravel	0.0
% Sand	1.7
% Fines	98.3
D_{60}	
D_{30}	
D_{10}	
C_u	
C_c	

Exploration	Sample No.	Depth (ft)	SYMBOL	Wn (%)	LL	PI	% Clay	Description and Classification
B-6	7	30.0	●		47	31	15	**Brown CLAY (CL)**

PROJECT NAME: **Imperial Valley Substation**

PROJECT NUMBER: **27668011**

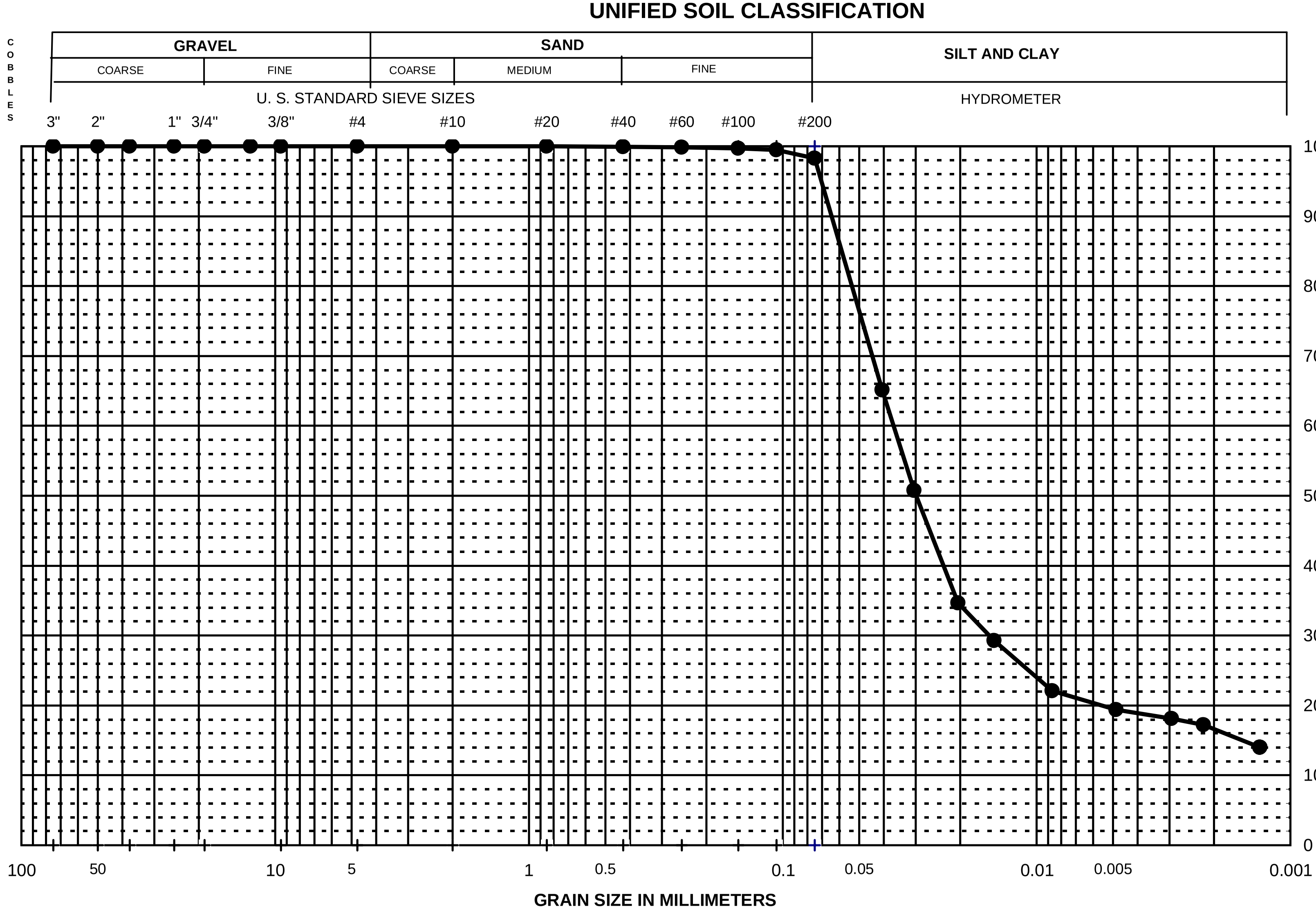
PARTICLE-SIZE DISTRIBUTION CURVES

Figure: D-5

(SNA) sieve only (04/2000)

Fig D5 Hydrometer IVS B06030

URS



Sieve No.	Dia. mm	% Finer
3"	75.0	100.0
2"	50.0	100.0
1.5"	37.5	100.0
1"	25.0	100.0
3/4"	19.00	100.0
1/2"	12.50	100.0
3/8"	9.50	100.0
#4	4.75	100.0
#10	2.00	100.0
#20	0.850	100.0
#40	0.425	99.9
#60	0.250	99.8
#100	0.150	99.7
#140	0.106	99.5
#200	0.075	98.2
Hydrometer Analysis	0.0405	65.1
	0.0304	50.8
	0.0204	34.6
	0.0147	29.2
	0.0087	22.1
	0.0049	19.4
	0.0029	18.1
	0.0022	17.2
	0.0013	14.0
	0.0013	14.0
% Cobbles		
% Gravel		0.0
% Sand		1.8
% Fines		98.2
D_{60}		
D_{30}		
D_{10}		
C_u		
C_c		

Exploration	Sample No.	Depth (ft)	SYMBOL	Wn (%)	LL	PI	% Clay	Description and Classification
B-3	8	35.0	●		31	9	17	**Light Brown CLAY (CL)**

PROJECT NAME: **Imperial Valley Substation**

PROJECT NUMBER: **27668011**

PARTICLE-SIZE DISTRIBUTION CURVES

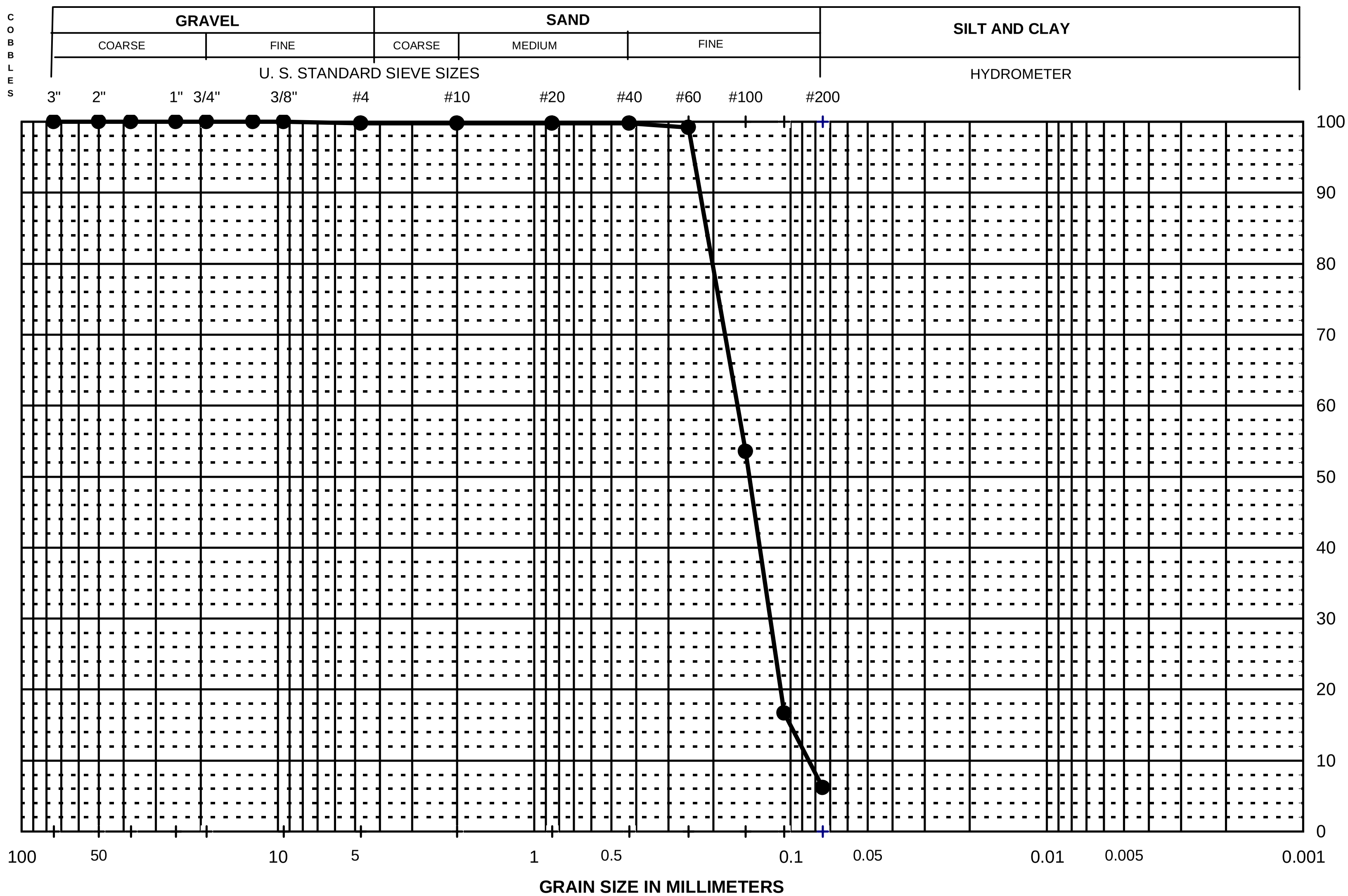
Figure: D-6

(SNA) sieve only (04/2000)

Fig D6 Hydrometer IVS B03035

URS

UNIFIED SOIL CLASSIFICATION



Sieve No.	Dia. mm	% Finer
3"	75.0	100.0
2"	50.0	100.0
1.5"	37.5	100.0
1"	25.0	100.0
3/4"	19.00	100.0
1/2"	12.50	100.0
3/8"	9.50	100.0
#4	4.75	99.8
#10	2.00	99.8
#20	0.850	99.8
#40	0.425	99.8
#60	0.250	99.1
#100	0.150	53.6
#140	0.106	16.7
#200	0.075	6.2
Hydrometer Analysis		

% Cobbles	
% Gravel	0.2
% Sand	93.6
% Fines	6.2
D_{60}	0.161
D_{30}	0.120
D_{10}	0.085
C_u	1.9
C_c	1.1

Exploration	Sample No.	Depth (ft)	SYMBOL	Wn (%)	LL	PI	% Clay	Description and Classification
B-7	7	30.0	●	2.5				**Brown poorly graded SAND with Silt (SP-SM)**

PROJECT NAME: **Imperial Valley Substation**

PROJECT NUMBER: **27668011**

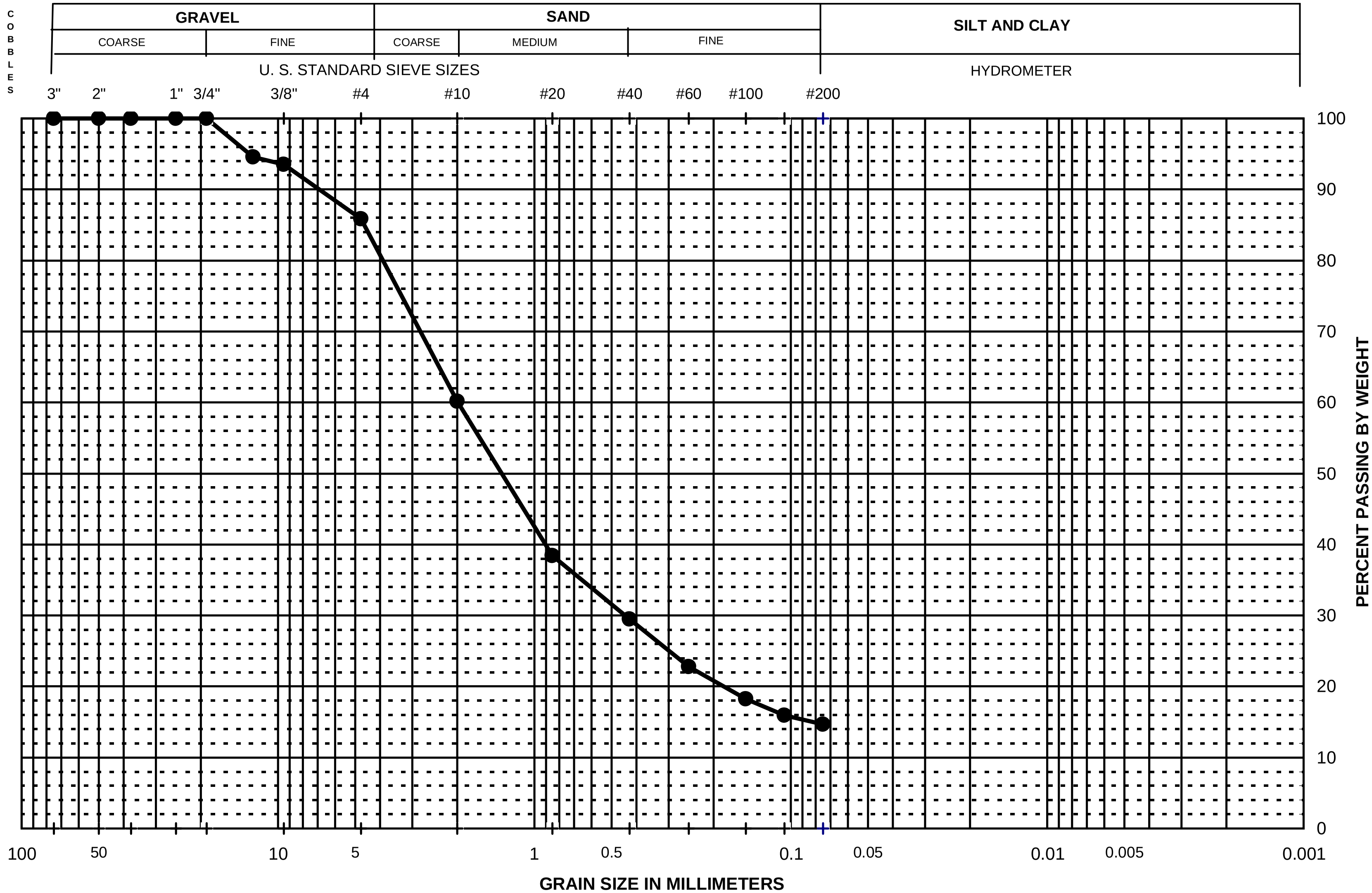
PARTICLE-SIZE DISTRIBUTION CURVES

Figure: D-7

Fig D7 Sieve IVS B07030

URS

UNIFIED SOIL CLASSIFICATION



Sieve No.	Dia. mm	% Finer
3"	75.0	100.0
2"	50.0	100.0
1.5"	37.5	100.0
1"	25.0	100.0
3/4"	19.00	100.0
1/2"	12.50	94.6
3/8"	9.50	93.5
#4	4.75	85.9
#10	2.00	60.1
#20	0.850	38.4
#40	0.425	29.5
#60	0.250	22.8
#100	0.150	18.2
#140	0.106	15.9
#200	0.075	14.6
Hydrometer Analysis		

% Cobbles	
% Gravel	14.1
% Sand	71.2
% Fines	14.6
D_{60}	
D_{30}	
D_{10}	
C_u	
C_c	

Exploration	Sample No.	Depth (ft)	SYMBOL	Wn (%)	LL	PI	% 5 µm	Description and Classification
B-8	8	35.0	●	13.3				**Light Brown Poorly Graded SAND with Silt (SP-SM)**

PROJECT NAME: **Imperial Valley Substation**
PROJECT NUMBER: **27668011**

PARTICLE-SIZE DISTRIBUTION CURVES

Figure: D-8

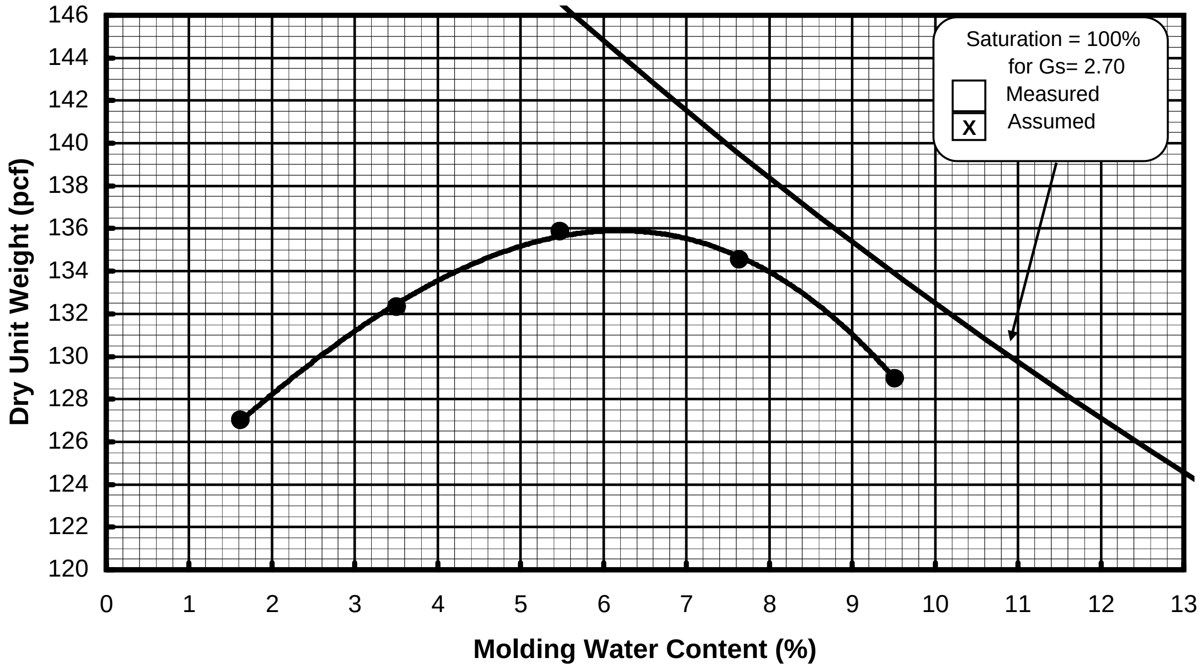
URS

Fig D8 Sieve IVS B08035

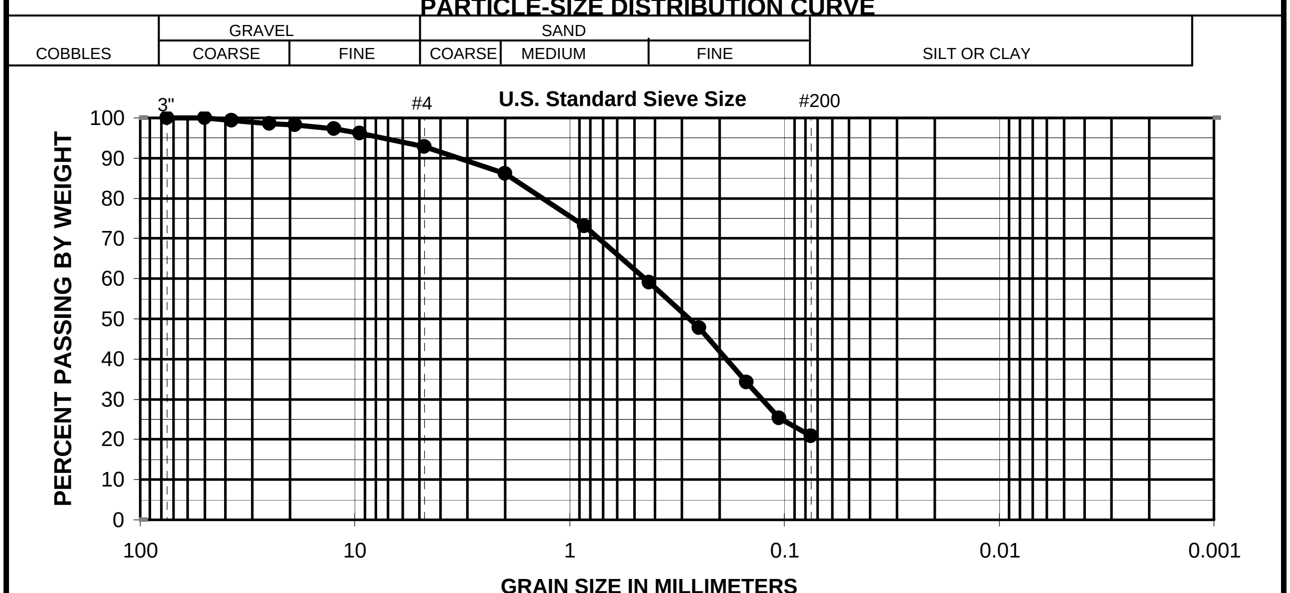
COMPACTION CURVE

Test Method: ● ASTM D 1557 ■ ASTM D 698 ◆ CA-DWR: S-10 ❍ Other Effort

Compaction Procedure: **B** Specimen Preparation Method: **Moist**



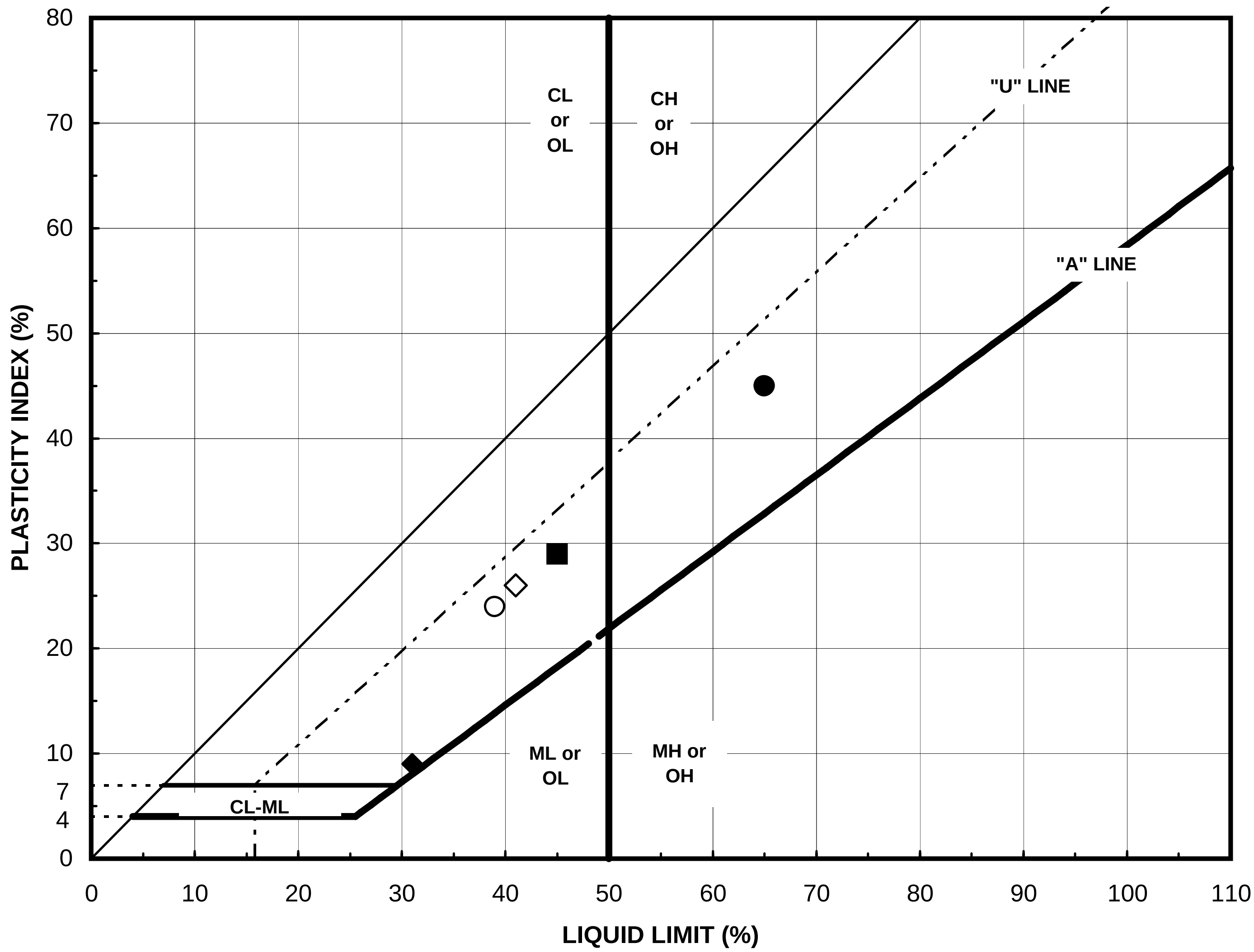
PARTICLE-SIZE DISTRIBUTION CURVE



NOTATION: ● Representative of entire sample ◆ Representative of compacted specimen ■ Representative of compacted specimen and entire sample

Exploration Number	Sample Number	Depth (ft.)	Optimum WC (%)	Maximum DUW (pcf)	Description and/or Classification
					Light Brown Silty SAND (SM)
B-4	bulk	3.5	6.5	136.0	

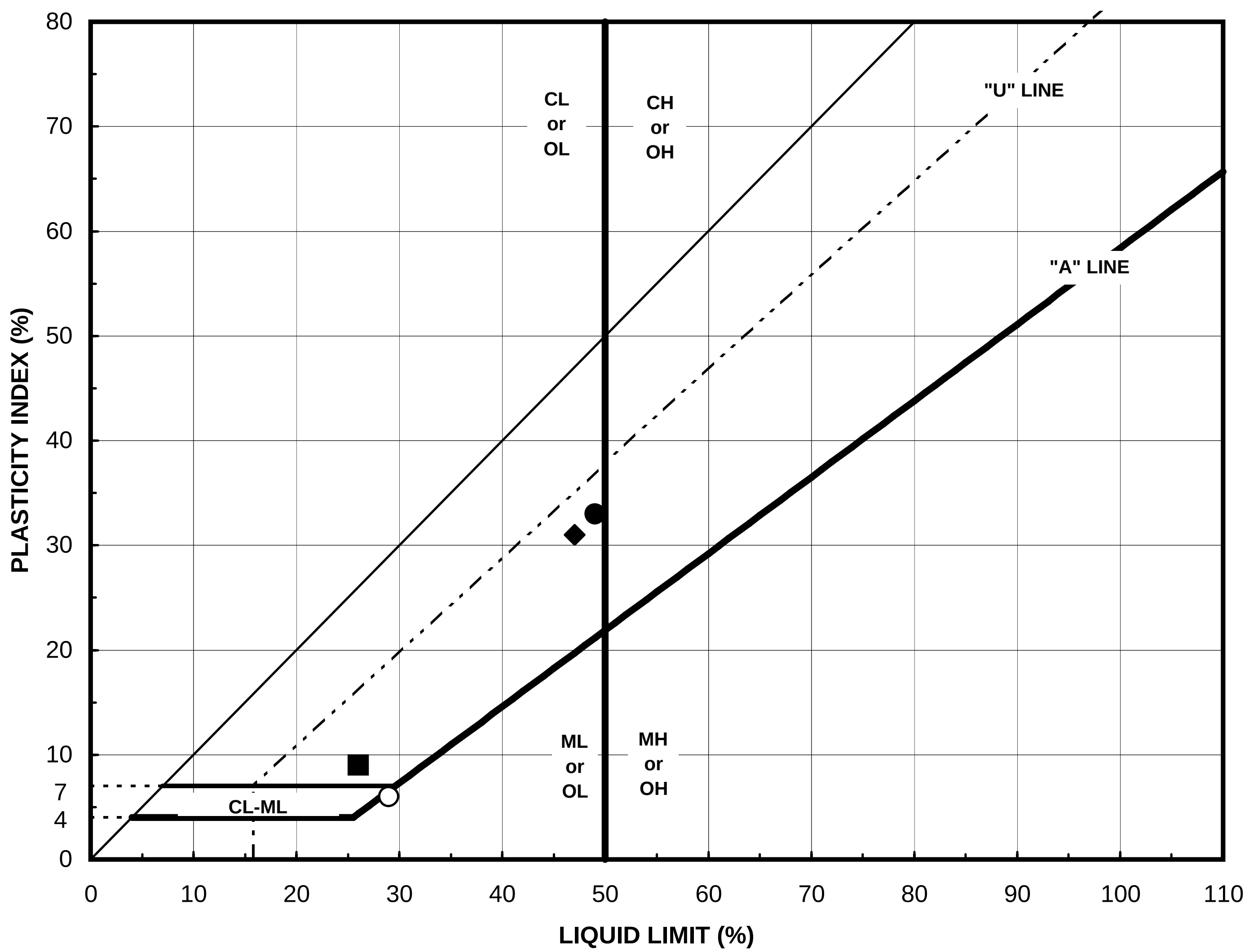
PROJECT NAME: **Imperial Valley Substation** **PROJECT NUMBER:** **27668011**	**COMPACTION AND INDEX PROPERTY DATA**	**Fig. D-9**



BORING / SAMPLE	DEPTH (feet)	TEST SYMBOL	WATER CONTENT (%)	LL	PI	DESCRIPTION / CLASSIFICATION
B-3	10.0	●	15.9	65	45	Brown CLAY (CH)
B-3	20.0	◇	10.9	41	26	Brown CLAY (CL)
B-3	30.0	■	25.2	45	29	Brown CLAY (CL)
B-3	35.0	◆	27.1	31	9	Brown CLAY (CL)
B-3	45.0	○	39.0	39	24	Brown CLAY (CL)

Project Name: **Imperial Valley Substation**
Project Number: **27668011**

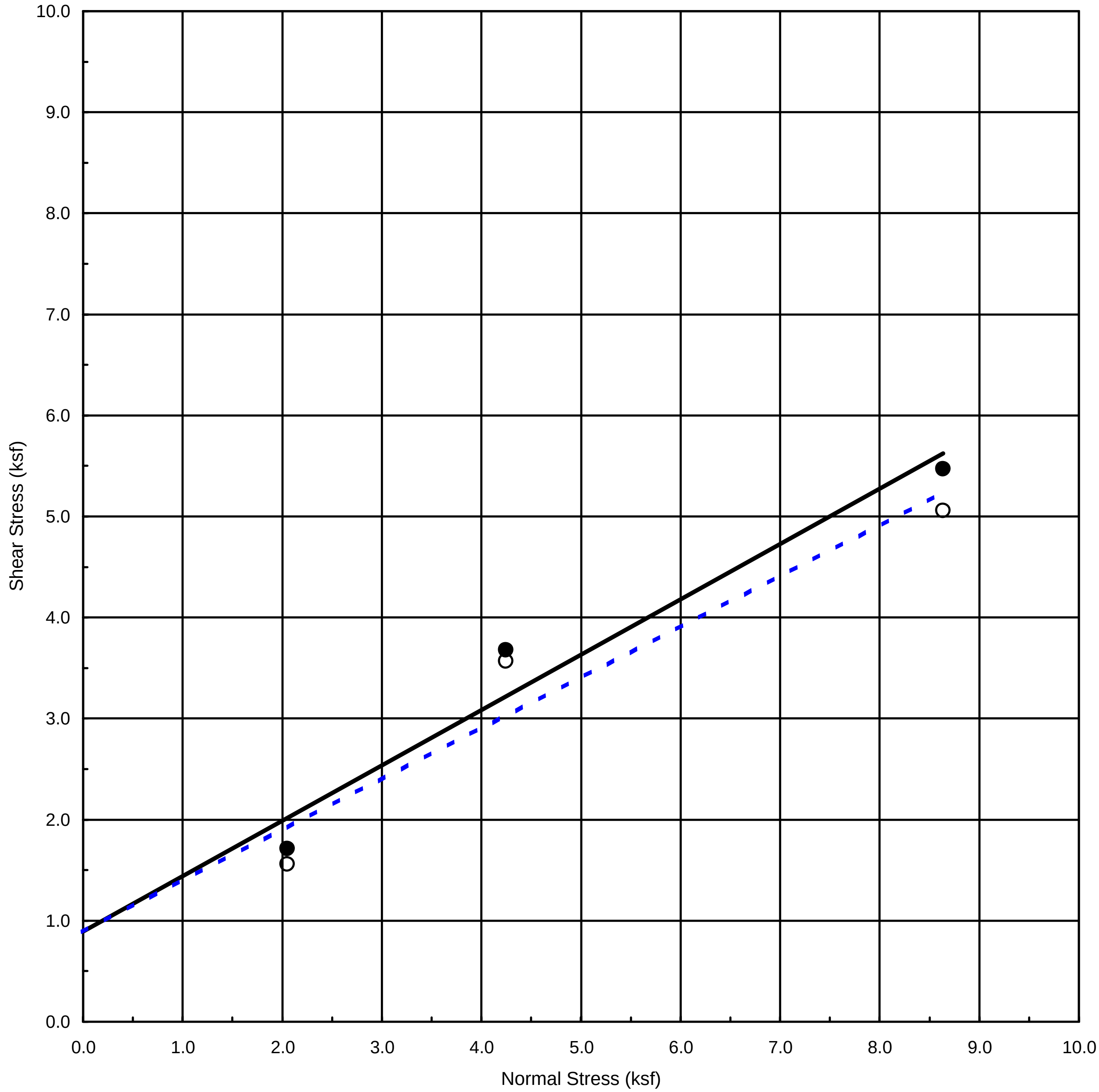
PLASTICITY CHART
Figure: D-10



BORING / SAMPLE	DEPTH (feet)	TEST SYMBOL	WATER CONTENT (%)	LL	PI	DESCRIPTION / CLASSIFICATION
B-4	45.0	●	29.8	49	33	Brown CLAY (CL)
B-5	40.0	■	27.4	26	9	Brown Sandy CLAY (CL)
B-6	30.0	◆		47	31	Brown CLAY (CL)
B-6	40.0	○		29	6	Brown Silt (ML)

Project Name: Imperial Valley Substation
Project Number: 27668011

PLASTICITY CHART
Figure: D-11



Peak Values are : ● ,solid trend line   Ultimate Values are: ❍ ,dashed trend line

Exploration No.:	B-2		Strength Intercept (C) :	0.90	ksf	Peak	0.89	ksf	Ultimate	
Sample No.:	4			42.9	kPa		42.6	kPa		
Depth (ft | m)	15	4.6	Friction Angle (ϕ) :	29	degree		27	degree		
Description:	**Brown CLAY (CL)**				Shear rate :	0.005	(in/min) ,	0.0127	(cm/min)	

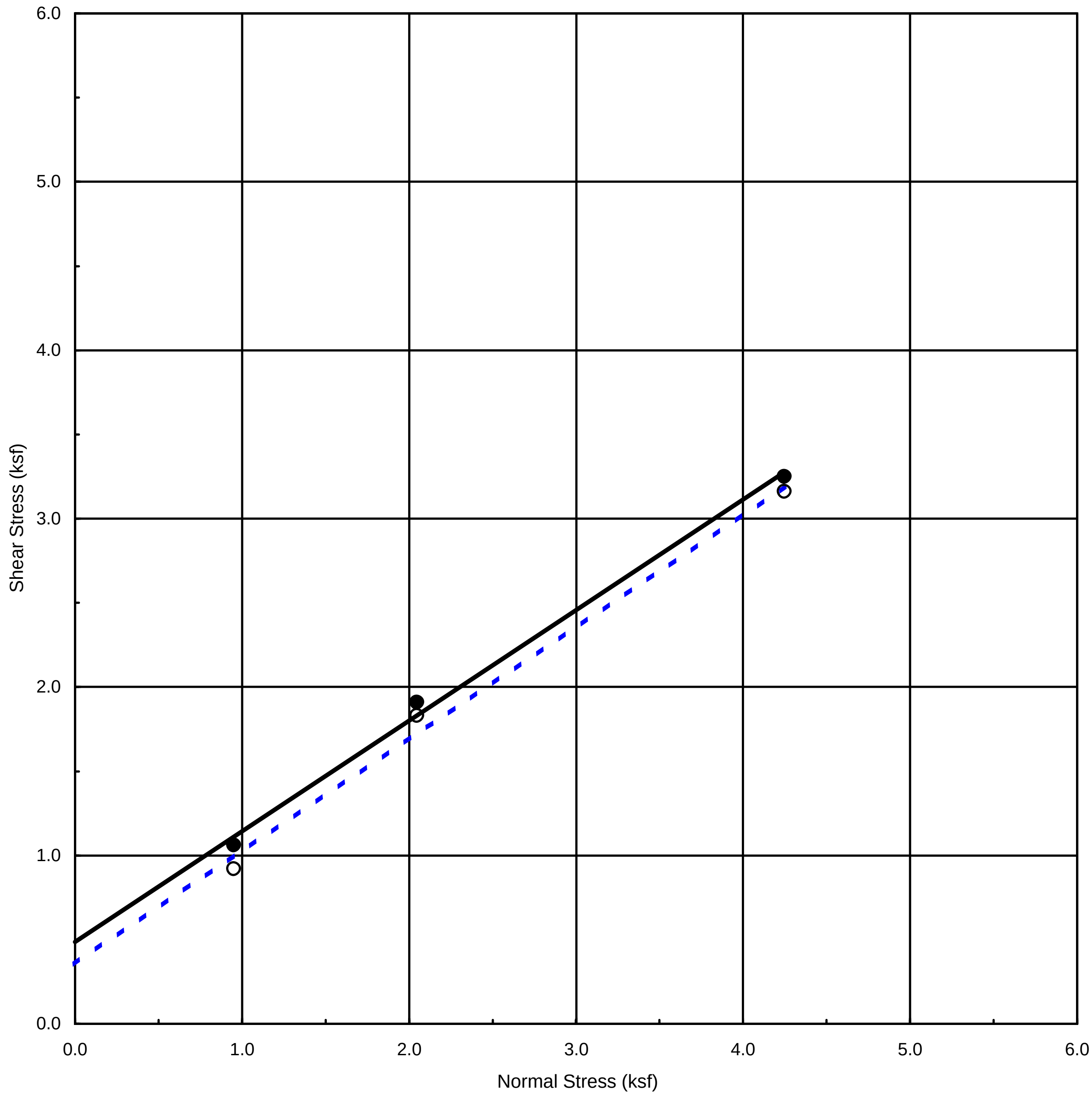
SYMBOL		% Water Content	Total Unit Weight (pcf)	Total Unit Weight (kN/m^3)	Dry Unit Weight (pcf)	Dry Unit Weight (kN/m^3)	Normal Stress (ksf)	Normal Stress (kPa)	Peak Stress (ksf)	Peak Stress (kPa)	Ultimate Stress (ksf)	Ultimate Stress (kPa)
Initial / Set up		3.1	100.9	15.9	97.9	15.4	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX
pre-shear	spec. 1	26.7	126.9	19.9	100.2	15.7	2.0	98.1	1.7	81.9	1.6	74.7
	spec. 2	26.8	132.0	20.7	104.1	16.4	4.2	203.3	3.7	176.2	3.6	170.9
	spec. 3	25.8	134.1	21.1	106.6	16.8	8.6	413.6	5.5	261.9	5.1	242.3

URS

Imperial Valley Substation

Project Number: 27668011   Date: 7/1/2008

DIRECT SHEAR TEST
ASTM D 3080
Figure: D-12



Peak Values are : ● ,solid trend line | Ultimate Values are: ○ ,dashed trend line

Exploration No.:	B-3	Strength Intercept (C) :	0.49 ksf / 23.4 kPa	Peak	0.35 ksf / 17.0 kPa	Ultimate
Sample No.:	2					
Depth (ft | m)	5 | 1.5	Friction Angle (ϕ) :	33 degree		34 degree	
Description:	**Light Brown CLAY (CL) to Clayey SAND (SC)**	Shear rate :	0.004 (in/min) ,		0.0102 (cm/min)	

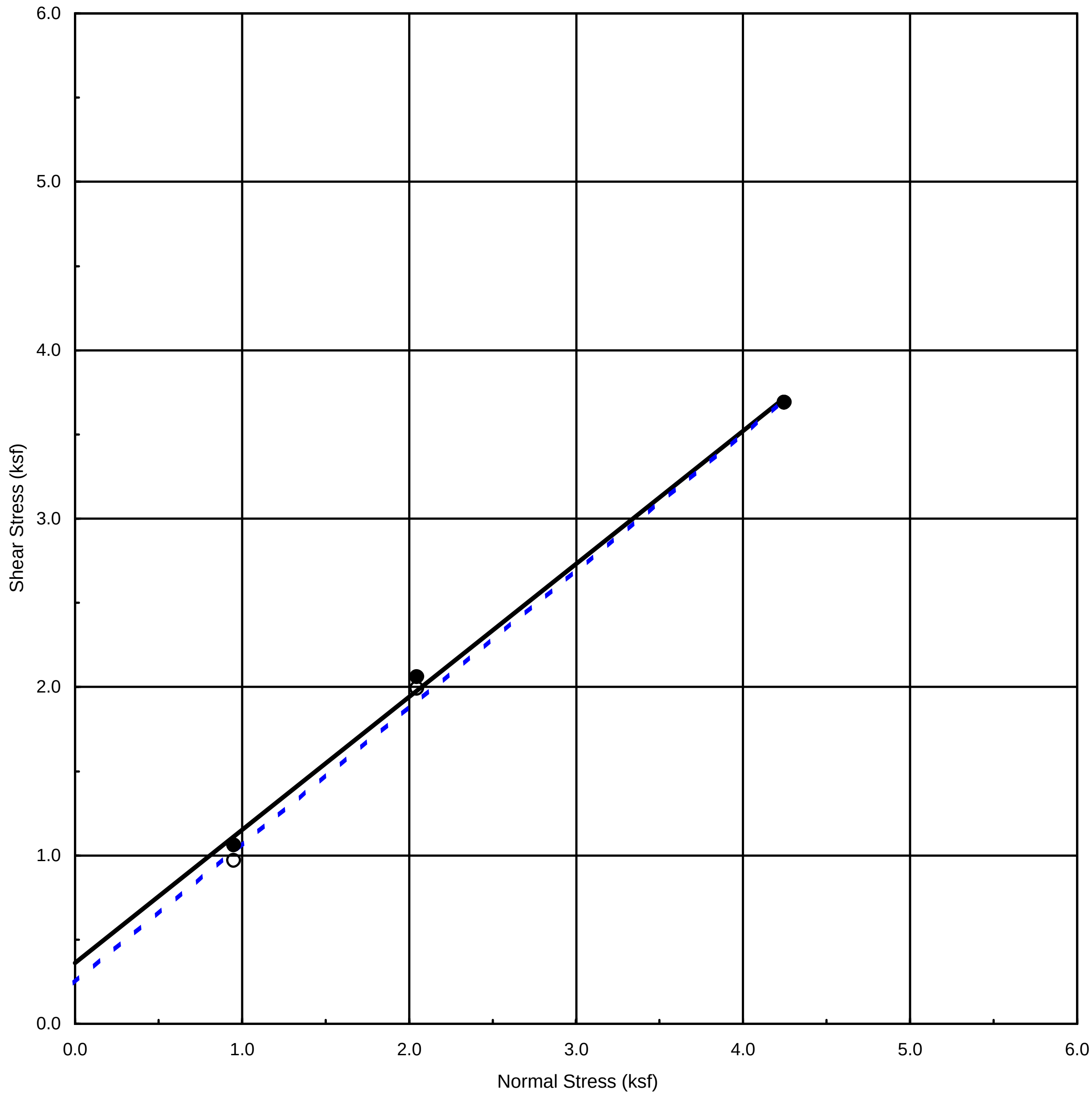
SYMBOL		% Water Content	Total Unit Weight (pcf)	Total Unit Weight (kN/m^3)	Dry Unit Weight (pcf)	Dry Unit Weight (kN/m^3)	Normal Stress (ksf)	Normal Stress (kPa)	Peak Stress (ksf)	Peak Stress (kPa)	Ultimate Stress (ksf)	Ultimate Stress (kPa)
Initial / Set up		5.0	122.0	19.2	116.2	18.3	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX
pre-shear	spec. 1	17.0	132.1	20.8	112.9	17.7	0.9	45.5	1.1	50.8	0.9	44.0
pre-shear	spec. 2	18.9	138.0	21.7	116.1	18.2	2.0	98.1	1.9	91.5	1.8	87.6
pre-shear	spec. 3	16.7	142.2	22.3	121.8	19.1	4.2	203.3	3.3	155.6	3.2	151.3

URS

Imperial Valley Substation

Project Number: 27668011 Date: 6/27/2008

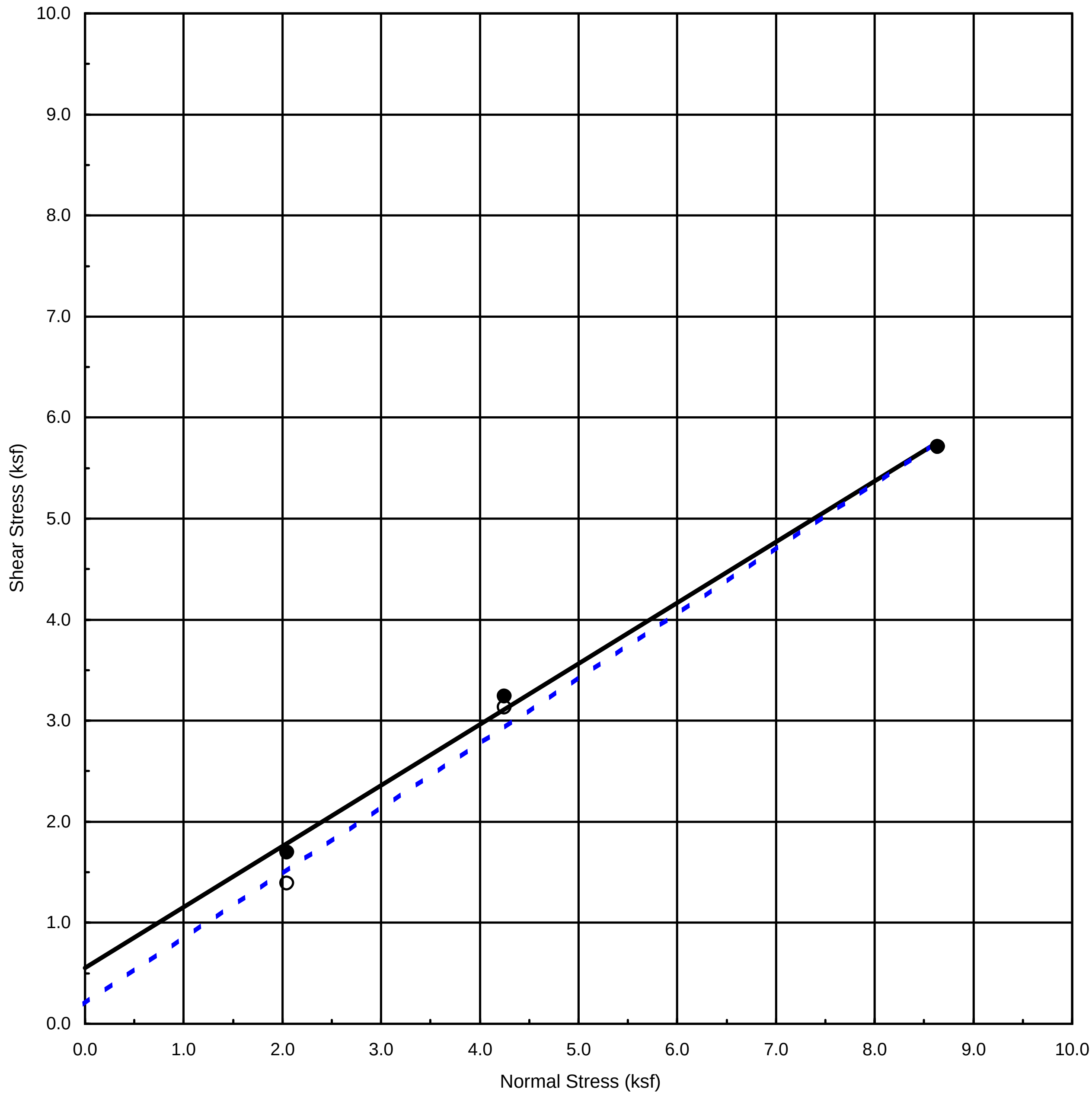
DIRECT SHEAR TEST
ASTM D 3080
Figure: D-13



Peak Values are :	●	,solid trend line				Ultimate Values are:	○	,dashed trend line			
Exploration No.:	B-6		Strength Intercept (C) :	0.36	ksf	Peak	0.24	ksf	Ultimate		
Sample No.:	2			17.4	kPa		11.6	kPa			
Depth (ft | m)	5	1.5	Friction Angle (ϕ) :	38	degree		39	degree			
Description:	**Light Brown SAND with Silt (SP-SM)**				Shear rate :	0.008	(in/min) ,	0.0203	(cm/min)		

SYMBOL		% Water Content	Total Unit Weight (pcf)	Total Unit Weight (kN/m^3)	Dry Unit Weight (pcf)	Dry Unit Weight (kN/m^3)	Normal Stress (ksf)	Normal Stress (kPa)	Peak Stress (ksf)	Peak Stress (kPa)	Ultimate Stress (ksf)	Ultimate Stress (kPa)
Initial / Set up		0.7	115.5	18.1	114.7	18.0	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX
pre-shear	spec. 1	17.2	127.3	20.0	108.6	17.1	0.9	45.5	1.1	50.8	1.0	46.4
	spec. 2	19.0	127.2	20.0	106.9	16.8	2.0	98.1	2.1	98.6	2.0	95.3
	spec. 3	19.1	139.1	21.9	116.8	18.3	4.2	203.3	3.7	176.7	3.7	176.7

URS	Imperial Valley Substation	DIRECT SHEAR TEST
	Project Number: 27668011 Date: 6/20/2008	ASTM D 3080 Figure: D-14



Peak Values are : ● ,solid trend line — Ultimate Values are: ❍ ,dashed trend line

Exploration No.:	B-6		Strength Intercept (C) :	0.55	ksf	Peak	0.19	ksf	Ultimate	
Sample No.:	4			26.5	kPa		9.3	kPa		
Depth (ft | m)	15	4.6	Friction Angle (ϕ) :	31	degree		33	degree		
Description:	**Light Brown Silty SAND (SM)**				Shear rate :	0.005	(in/min) ,	0.0127	(cm/min)	
SYMBOL	% Water Content	Total Unit Weight (pcf)	Total Unit Weight (kN/m^3)	Dry Unit Weight (pcf)	Dry Unit Weight (kN/m^3)	Normal Stress (ksf)	Normal Stress (kPa)	Peak Stress (ksf)	Peak Stress (kPa)	Ultimate Stress (ksf)	Ultimate Stress (kPa)
Initial / Set up	1.5	107.8	16.9	106.2	16.7	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX
pre-shear spec. 1	18.9	129.6	20.4	109.0	17.1	2.0	98.1	1.7	81.4	1.4	66.6
pre-shear spec. 2	20.3	131.3	20.6	109.1	17.1	4.2	203.3	3.2	155.1	3.1	149.9
pre-shear spec. 3	23.3	131.8	20.7	106.9	16.8	8.6	413.6	5.7	273.4	5.7	273.4

URS

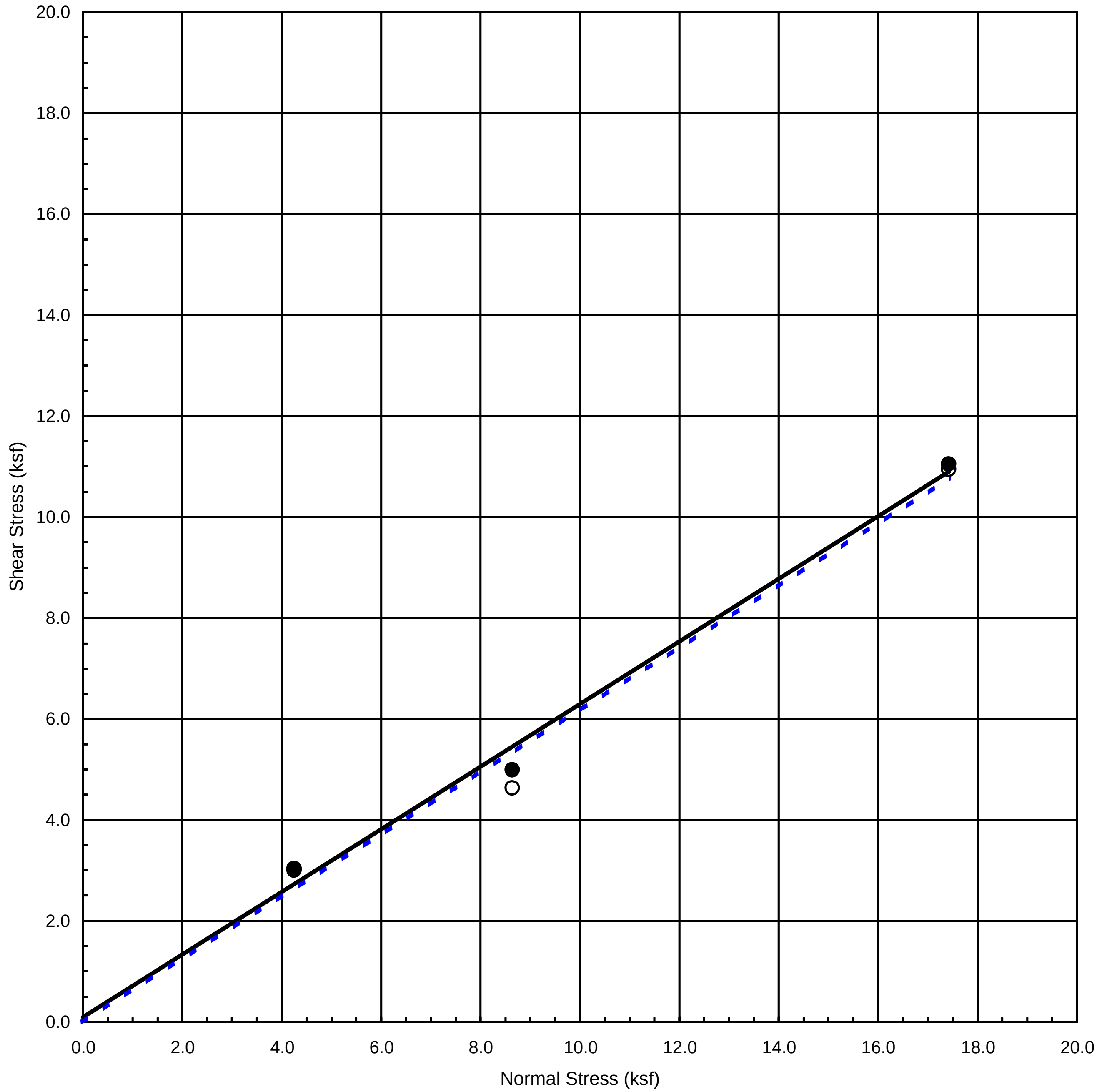
Imperial Valley Substation

Project Number: 27668011 Date: 6/25/2008

DIRECT SHEAR TEST

ASTM D 3080

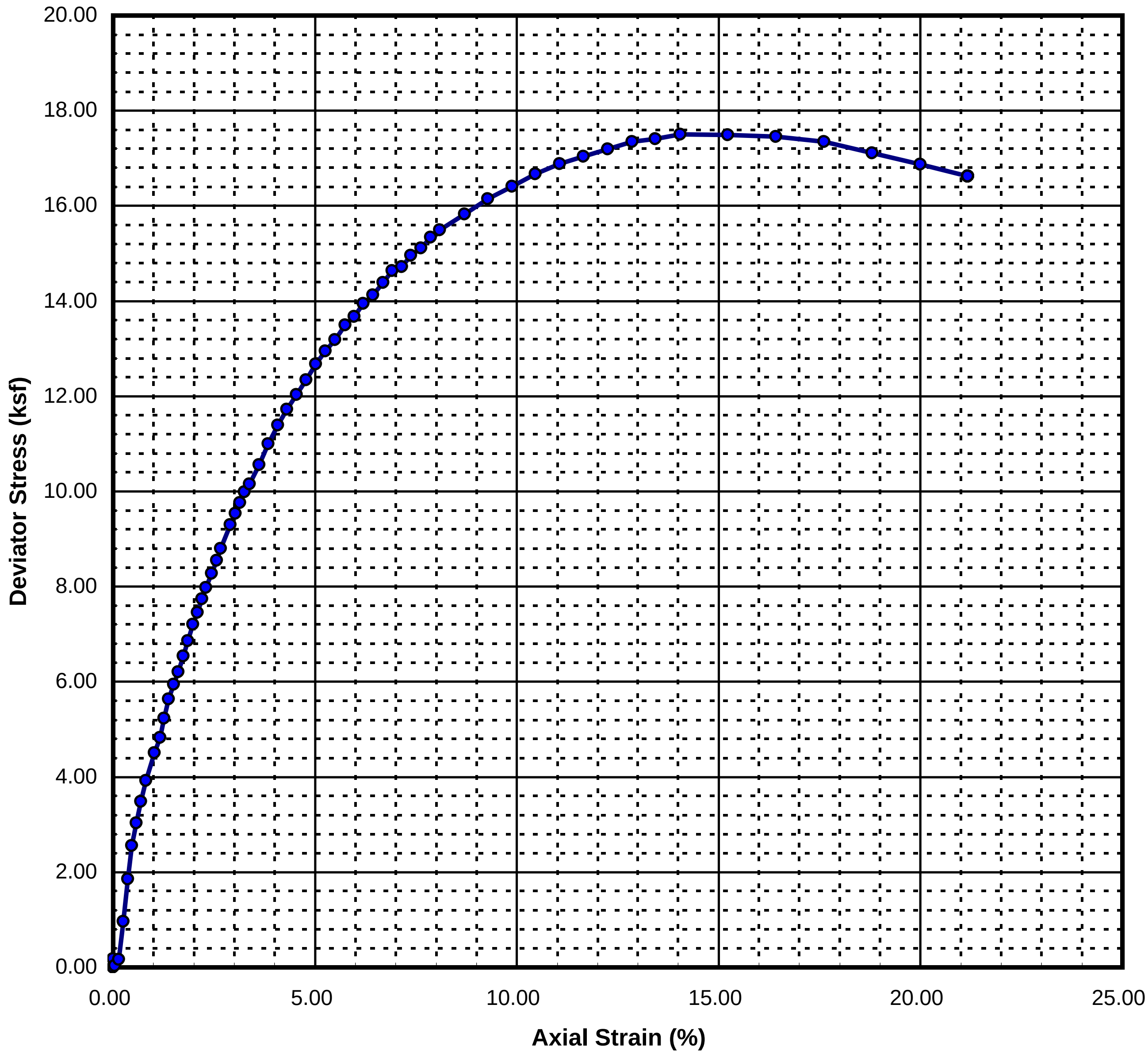
Figure: D-15



Peak Values are : ● ,solid trend line   Ultimate Values are: ❍ ,dashed trend line

Exploration No.:	B-6		Strength Intercept (C) :		0.09	ksf	Peak	0.00	ksf	Ultimate	
Sample No.:	10				4.3	kPa		0.0	kPa		
Depth (ft | m)	45	13.7	Friction Angle (ϕ) :		32	degree		32	degree		
Description:	**Brown Silt (ML)**					Shear rate :	0.002	(in/min) ,	0.0051	(cm/min)	
SYMBOL	% Water Content	Total Unit Weight (pcf)	Total Unit Weight (kN/m^3)	Dry Unit Weight (pcf)	Dry Unit Weight (kN/m^3)	Normal Stress (ksf)	Normal Stress (kPa)	Peak Stress (ksf)	Peak Stress (kPa)	Ultimate Stress (ksf)	Ultimate Stress (kPa)
Initial / Set up	27.4	122.0	19.2	95.8	15.0	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX
pre-shear spec. 1	28.7	128.6	20.2	99.9	15.7	4.2	203.3	3.0	145.1	3.0	143.6
pre-shear spec. 2	28.2	132.2	20.8	103.1	16.2	8.6	413.6	5.0	238.9	4.6	221.7
pre-shear spec. 3	26.5	131.8	20.7	104.2	16.4	17.4	834.2	11.1	529.1	10.9	523.8

URS	**Imperial Valley Substation** Project Number: 27668011 Date: 7/3/2008	**DIRECT SHEAR TEST** **ASTM D 3080** **Figure: D-16**



Cell Pressure (ksf) = 5.00

Strain Rate (%/min) = 1.15

Axial Strain during confinment (%): 1.39

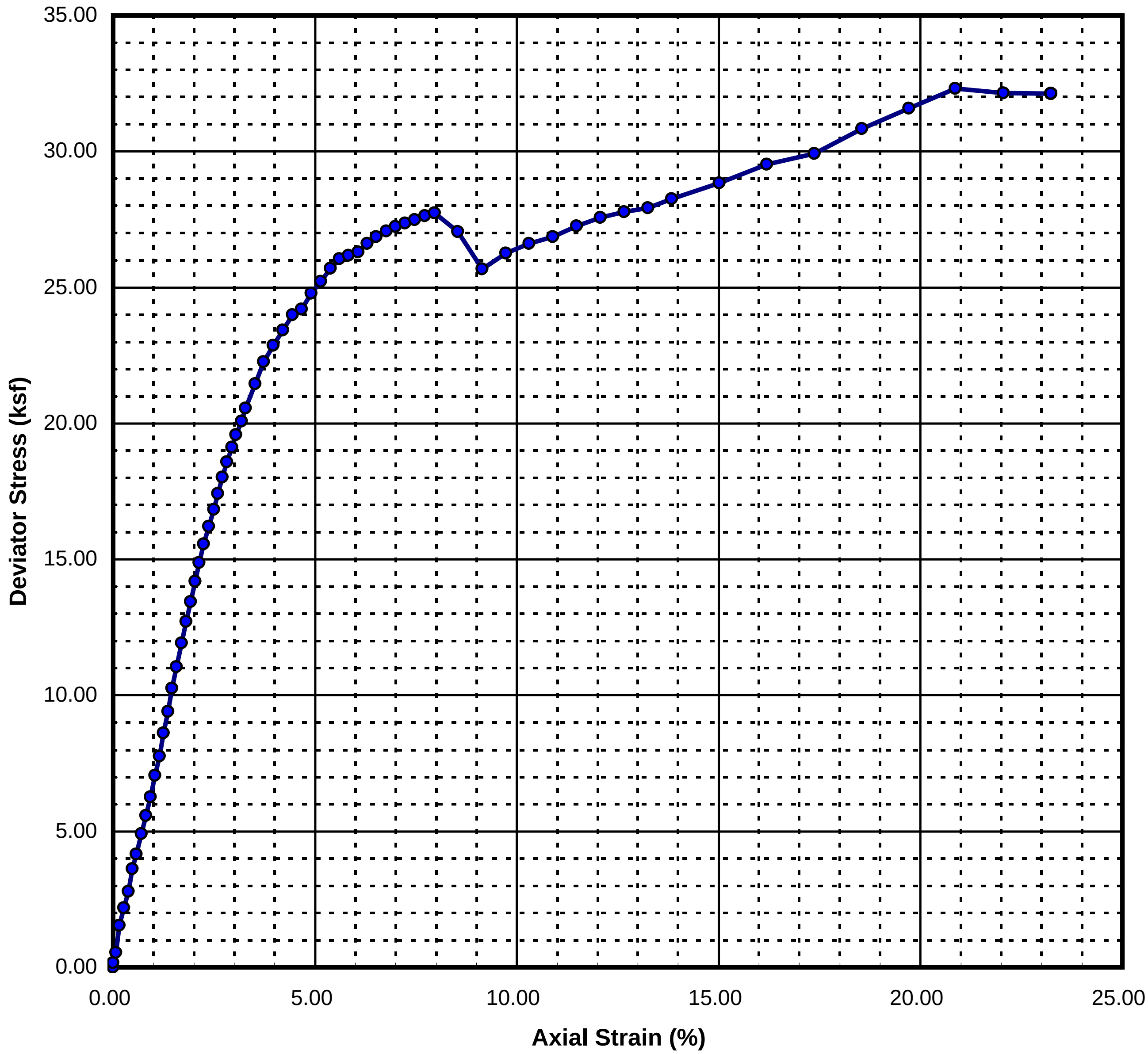
Peak Deviator Stress (ksf): 17.50

Test Number	Water Content (%)	LL (%)	PI (%)	Length (in)	Diameter (in)	Wet Unit Weight (pcf)	Degree of Saturation (%)
Initial:	12.9			3.888	1.923	110.5	48.3

Project Name:	**Imperial Valley Substation**
Project Number:	**27668011**
Exploration No:	**B-2** **Sample No.:** **2** **Depth (ft):** **5.0**
Description and/or Classification:	**Brown CLAY (CL)**

UNCONSOLIDATED - UNDRAINED TRIAXIAL COMPRESSION TEST

Figure: D-17



Cell Pressure (ksf) = 2.51

Strain Rate (%/min) = 1.16

Axial Strain during confinment (%): 0.39

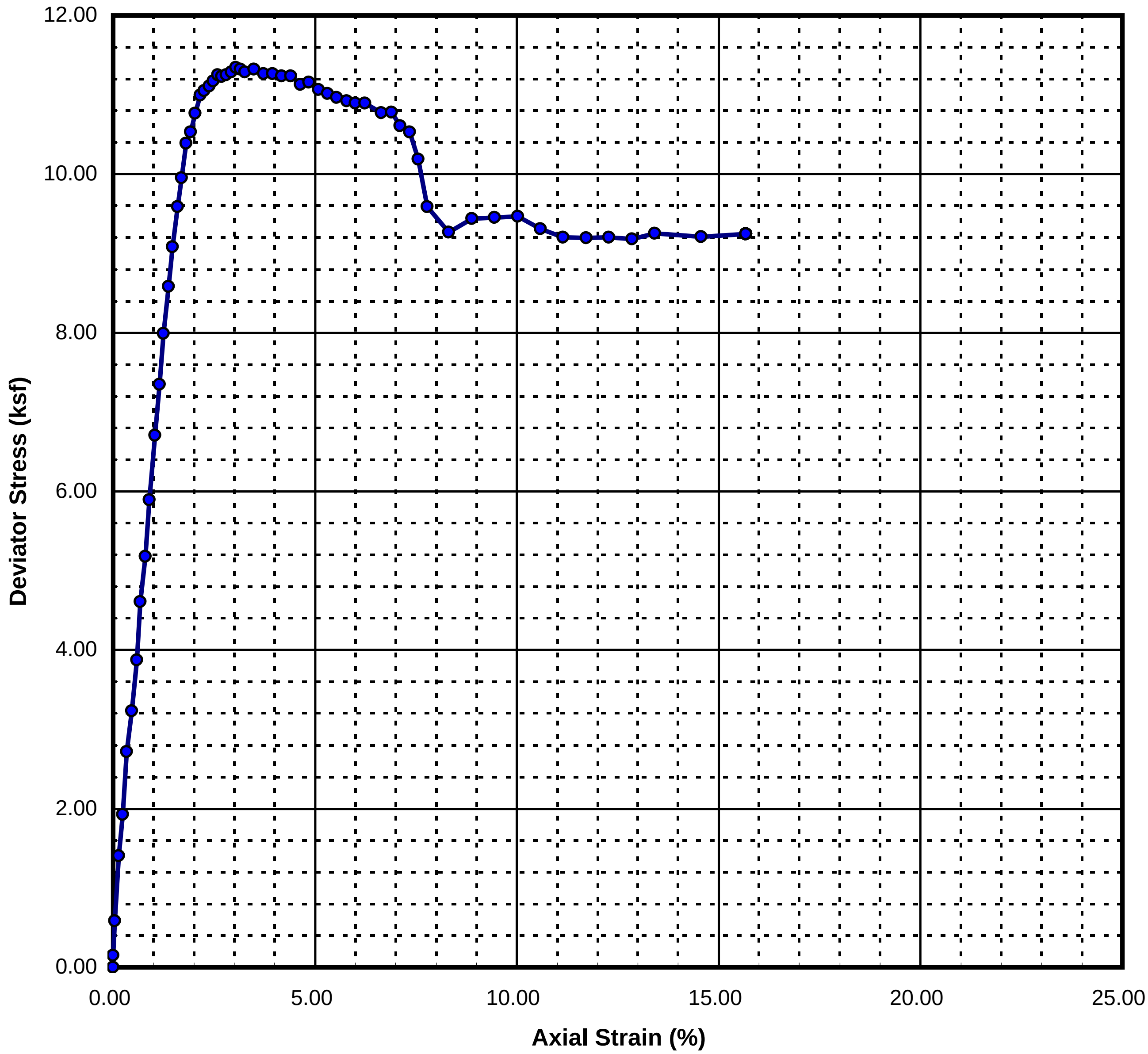
Peak Deviator Stress (ksf): 32.31

Test Number	Water Content (%)	LL (%)	PI (%)	Length (in)	Diameter (in)	Wet Unit Weight (pcf)	Degree of Saturation (%)
Initial:	8.2			3.884	1.938	108.7	32.8

Project Name:	**Imperial Valley Substation**
Project Number:	**27668011**
Exploration No:	**B-2** **Sample No.:** **6** **Depth (ft):** **25.0**
Description and/or Classification:	**Light Brown CLAY (CL)**

UNCONSOLIDATED - UNDRAINED TRIAXIAL COMPRESSION TEST

Figure: D-18



Cell Pressure (ksf) = 2.51

Strain Rate (%/min) = 1.11

Peak Deviator Stress (ksf): 11.34

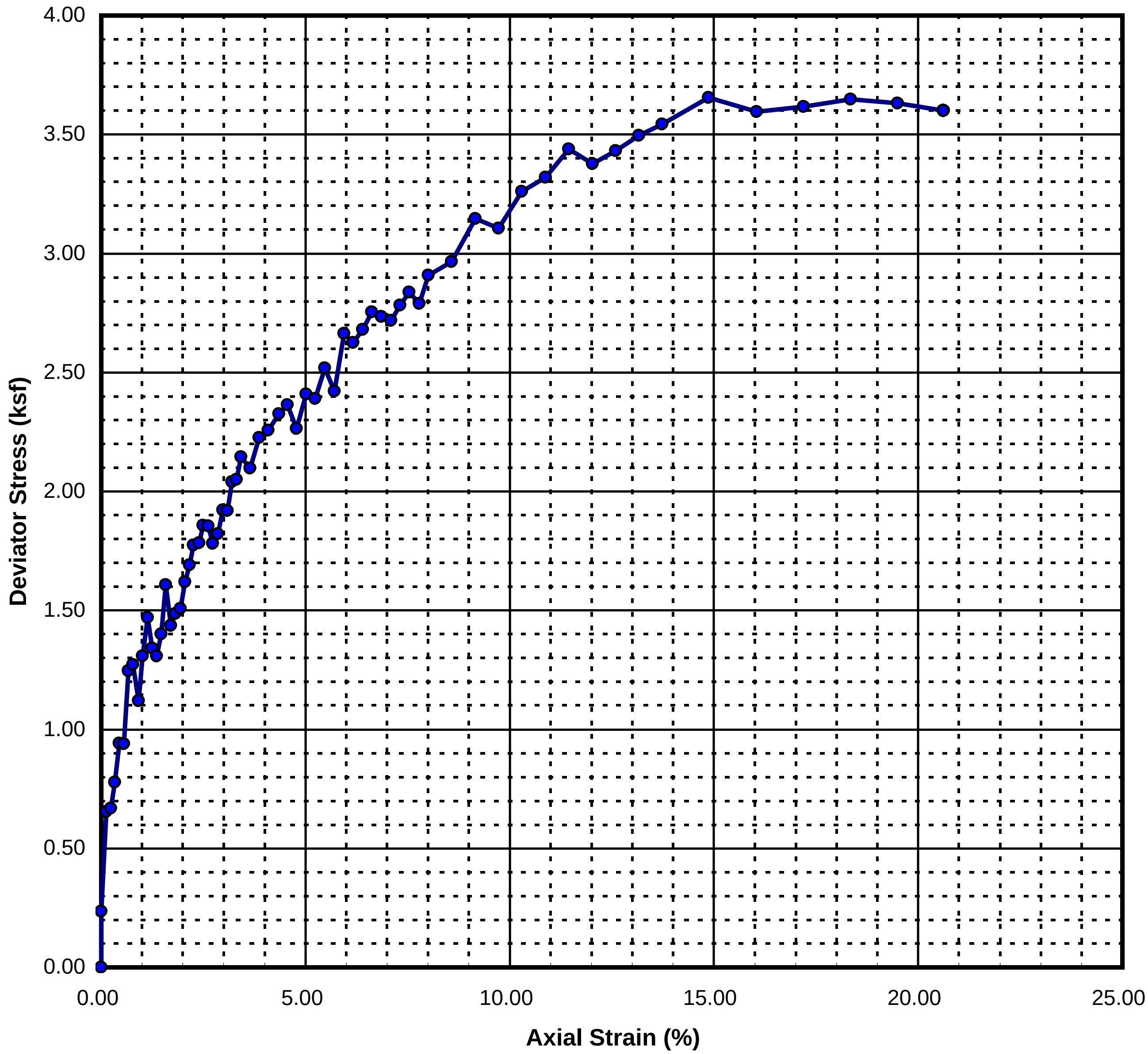
Axial Strain during confinment (%): 0.37

Test Number	Water Content (%)	LL (%)	PI (%)	Length (in)	Diameter (in)	Wet Unit Weight (pcf)	Degree of Saturation (%)
Initial:	6.3			4.036	1.936	99.9	21.5

Project Name:	**Imperial Valley Substation**
Project Number:	**27668011**
Exploration No:	**B-3** **Sample No.:** **6** **Depth (ft):** **25.0**
Description and/or Classification:	**Light Brown CLAY (CL)**

UNCONSOLIDATED - UNDRAINED TRIAXIAL COMPRESSION TEST

Figure: D-19



Cell Pressure (ksf) = 4.51

Strain Rate (%/min) = 1.12

Peak Deviator Stress (ksf): 3.66

Axial Strain during confinment (%): 0.90

Test Number	Water Content (%)	LL (%)	PI (%)	Length (in)	Diameter (in)	Wet Unit Weight (pcf)	Degree of Saturation (%)
Initial:	24.6	39	24	4.011	1.929	126.5	101.0

Project Name:	**Imperial Valley Substation**		**UNCONSOLIDATED - UNDRAINED TRIAXIAL COMPRESSION TEST**
Project Number:	**27668011**		
Exploration No:	**B-3**	**Sample No.: 10 Depth (ft): 45.0**	
Description and/or Classification:	**Brown CLAY (CL)**		**Figure: D-20**

CORROSIVITY TEST ANALYSIS

Project Number: 27668011 | Exploration No.: B-1
Project Name: Imperial Valley Substation | Sample No.: 1
Project Engineer: KG | Depth (ft): 3.0

Initial Visual Classification Symbol: SC

State of Specimen before Processing

X	Passing soil through #8 sieve
X	Moist State
	Air Dried
	Oven Dried at 60 C

Set-Up Water Content	Minus No. 8 or ( )
Container No.	x31
Mass Container + Wet Soil (g), M1	168.63
Mass Container + Dry Soil (g), M2	166.56
Mass Container (g), M3	134.54
Water Content, w (%)	6.46

Resistivity Test: California Test Method 643

Mininum Resistence value: 1,750 ohm-cm

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Weight of Soil in bowl (g):	689.75	707.98	711.12	713.9	
Weight of mixing bowl (g):	509.16	509.16	509.16	509.16	
Wet weight of Soil (g):	180.59	198.82	201.96	204.74	
Amount of water added (ml):	0	20	5	5	
Soil Box + Wet Soil (g), M5	259.11	267.26	266.76	266.23	
Weight of Soil Box (g), M6	127.18	127.18	127.18	127.18	
Wt. of Wet Soil for test (g), M7	131.93	140.08	139.58	139.05	
Volume of Soil Box (cm^3)	79.2	79.2	79.2	79.2	79.2
Est. Saturation (%)	24.2	38.3	40.3	39.9	
Soil Box Constant (cm)	1.00	1.00	1.00	1.00	1.00
Resistivity Reading (ohm)	3,500	1,900	1,750	1,750	
Resistence (ohm-cm)	3,500	1,900	1,750	1,750	

Resistence = Soil Box Constant x Reading

pH Test : California Test Method 532

50g wet weight of soil mixed with 50 mL of de-ionized water.

pH of slurry: 8.93
Temperature : 24.0 Celsius

Sulfate Content: California Test Method 417

100g of soil mixed with 300 mL of de-ionized water.

SO_4 (ppm) : 784

mg /kg of SO_4 = (mg of SO_4 X 3000) / mL of sample

recorded mg of SO_4 in sample = 49 mg

above value X = 16 = 784 mg/ L = ppm

Chloride Content: California Test Method 422

100g of soil mixed with 300 mL of de-ionized water.

Cl^- (ppm) : 285

mg/L of Cl^- = ((A-B) x N x 35453) x 3

A = mL of $AgNO_3$ A= 19

B = 23 mL of the blank

N = 0.0493 N, normality of the titrant

Cl^- (mg/L) = A * 5 * 3

Tested By: BG Date: 6/11/2008 Checked By: TJO

URS

Figure : D-21

CORROSIVITY TEST ANALYSIS

Project Number: 27668011
Project Name: Imperial Valley Substation
Project Engineer: KG

Exploration No.: B-1
Sample No.: 3
Depth (ft): 10.0

Initial Visual Classification Symbol: CL

State of Specimen before Processing

- [X] Passing soil through #8 sieve
- [X] Moist State
- [ ] Air Dried
- [ ] Oven Dried at 60 C

Set-Up Water Content	Minus No. 8 or ( )
Container No.	sf4
Mass Container + Wet Soil (g), M1	181.83
Mass Container + Dry Soil (g), M2	174.11
Mass Container (g), M3	130.61
Water Content, w (%)	17.75

Resistivity Test: California Test Method 643

Mininum Resistence value: 350 ohm-cm

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Weight of Soil in bowl (g):	744.42	760.65	775.26		
Weight of mixing bowl (g):	507.34	507.34	507.34		
Wet weight of Soil (g):	237.08	253.31	267.92		
Amount of water added (ml):	0	20	20		
Soil Box + Wet Soil (g), M5	253.66	261.15	256.84		
Weight of Soil Box (g), M6	127.40	127.40	127.40		
Wt. of Wet Soil for test (g), M7	126.26	133.75	129.44		
Volume of Soil Box (cm^3)	79.2	79.2	79.2	79.2	79.2
Est. Saturation (%)	48.4	60.6	61.9		
Soil Box Constant (cm)	1.00	1.00	1.00	1.00	1.00
Resistivity Reading (ohm)	570	350	350		
Resistence (ohm-cm)	570	350	350		

Resistence = Soil Box Constant x Reading

pH Test : California Test Method 532

50g wet weight of soil mixed with 50 mL of de-ionized water.

pH of slurry: 8.19
Temperature : 24.2 Celsius

Sulfate Content: California Test Method 417

100g of soil mixed with 300 mL of de-ionized water.

SO_4 (ppm) : 368

mg /kg of SO_4 = (mg of SO_4 X 3000) / mL of sample

recorded mg of SO_4 in sample = 23 mg

above value X = 16 = 368 mg/ L = ppm

Chloride Content: California Test Method 422

100g of soil mixed with 300 mL of de-ionized water.

Cl^- (ppm) : 420

mg/L of Cl^- = ((A-B) x N x 35453) x 3

A = mL of $AgNO_3$ A= 28

B = 23 mL of the blank

N = 0.0493 N, normality of the titrant

Cl^- (mg/L) = A * 5 * 3

Tested By: BG Date: 6/11/2008 Checked By: TJO

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CORROSIVITY TEST ANALYSIS

Project Number: 27668011

Project Name: Imperial Valley Substation

Project Engineer: KG

Exploration No.: B-1

Sample No.: 7

Depth (ft): 30.0

Initial Visual Classification Symbol: CL

State of Specimen before Processing

X	Passing soil through #8 sieve
X	Moist State
	Air Dried
	Oven Dried at 60 C

Set-Up Water Content	Minus No. 8 or ( )
Container No.	x18
Mass Container + Wet Soil (g), M1	139.4
Mass Container + Dry Soil (g), M2	137.67
Mass Container (g), M3	127.6
Water Content, w (%)	17.18

Resistivity Test: California Test Method 643

Mininum Resistence value: 240 ohm-cm

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Weight of Soil in bowl (g):	631.35	640.08	646.6	650.57	
Weight of mixing bowl (g):	510.66	510.66	510.66	510.66	
Wet weight of Soil (g):	120.69	129.42	135.94	139.91	
Amount of water added (ml):	0	10	10	10	
Soil Box + Wet Soil (g), M5	252.04	258.27	262.09	265.26	
Weight of Soil Box (g), M6	130.93	130.93	130.93	130.93	
Wt. of Wet Soil for test (g), M7	121.11	127.34	131.16	134.33	
Volume of Soil Box (cm^3)	79.2	79.2	79.2	79.2	79.2
Est. Saturation (%)	43.5	51.6	58.2	61.1	
Soil Box Constant (cm)	1.00	1.00	1.00	1.00	1.00
Resistivity Reading (ohm)	470	260	240	240	
Resistence (ohm-cm)	470	260	240	240	

Resistence = Soil Box Constant x Reading

pH Test : California Test Method 532

50g wet weight of soil mixed with 50 mL of de-ionized water.

pH of slurry: 8.05

Temperature : 24.4 Celsius

Sulfate Content: California Test Method 417

100g of soil mixed with 300 mL of de-ionized water.

SO_4 (ppm) : 544

mg /kg of SO_4 = (mg of SO_4 X 3000) / mL of sample

recorded mg of SO_4 in sample = 34 mg

above value X = 16 = 544 mg/ L = ppm

Chloride Content: California Test Method 422

100g of soil mixed with 300 mL of de-ionized water.

Cl^- (ppm) : 765

mg/L of Cl^- = ((A-B) x N x 35453) x 3

A = mL of $AgNO_3$ A= 51

B = 23 mL of the blank

N = 0.0493 N, normality of the titrant

Cl^- (mg/L) = A * 5 * 3

Tested By: BG Date: 6/11/2008 Checked By: TJO

URS

CORROSIVITY TEST ANALYSIS

Project Number: 27668011
Project Name: Imperial Valley Substation
Project Engineer: KG

Exploration No.: B-6
Sample No.: 3
Depth (ft): 10.0

Initial Visual Classification Symbol: SM

State of Specimen before Processing

X	Passing soil through #8 sieve
X	Moist State
	Air Dried
	Oven Dried at 60 C

Set-Up Water Content	Minus No. 8 or ( )
Container No.	sna1
Mass Container + Wet Soil (g), M1	194.03
Mass Container + Dry Soil (g), M2	191.61
Mass Container (g), M3	145.65
Water Content, w (%)	5.27

Resistivity Test: California Test Method 643

Mininum Resistence value: 2,500 ohm-cm

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Weight of Soil in bowl (g):	772.06	789.65	805.49	813.98	
Weight of mixing bowl (g):	510.9	510.9	510.9	510.9	
Wet weight of Soil (g):	261.16	278.75	294.59	303.08	
Amount of water added (ml):	0	20	20	10	
Soil Box + Wet Soil (g), M5	256.83	272.97	282.20	273.71	
Weight of Soil Box (g), M6	131.69	131.69	131.69	131.69	
Wt. of Wet Soil for test (g), M7	125.14	141.28	150.51	142.02	
Volume of Soil Box (cm^3)	79.2	79.2	79.2	79.2	79.2
Est. Saturation (%)	17.9	33.9	50.4	38.9	
Soil Box Constant (cm)	1.00	1.00	1.00	1.00	1.00
Resistivity Reading (ohm)	8,100	3,500	2,500	2,600	
Resistence (ohm-cm)	8,100	3,500	2,500	2,600	

Resistence = Soil Box Constant x Reading

pH Test : California Test Method 532

50g wet weight of soil mixed with 50 mL of de-ionized water.

pH of slurry: 8.47
Temperature : 23.9 Celsius

Sulfate Content: California Test Method 417

100g of soil mixed with 300 mL of de-ionized water.

SO_4 (ppm) : 736

mg /kg of SO_4 = (mg of SO_4 X 3000) / mL of sample

recorded mg of SO_4 in sample = 46 mg

above value X = 16 = 736 mg/ L = ppm

Chloride Content: California Test Method 422

100g of soil mixed with 300 mL of de-ionized water.

Cl^- (ppm) : 240

mg/L of Cl^- = ((A-B) x N x 35453) x 3

A = mL of $AgNO_3$ A= 16

B = 23 mL of the blank

N = 0.0493 N, normality of the titrant

Cl^- (mg/L) = A * 5 * 3

Tested By: BG Date: 6/11/2008 Checked By: TJO

URS

CORROSIVITY TEST ANALYSIS

Project Number: 27668011
Project Name: Imperial Valley Substation
Project Engineer: KG

Exploration No.: B-7
Sample No.: 1
Depth (ft): 1.0

Initial Visual Classification Symbol: SM

State of Specimen before Processing

X	Passing soil through #8 sieve
X	Moist State
	Air Dried
	Oven Dried at 60 C

Set-Up Water Content	Minus No. 8 or ( )
Container No.	x15
Mass Container + Wet Soil (g), M1	178.1
Mass Container + Dry Soil (g), M2	177.21
Mass Container (g), M3	149.31
Water Content, w (%)	3.19

Resistivity Test: California Test Method 643

Mininum Resistence value: 5,000 ohm-cm

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Weight of Soil in bowl (g):	224.56	228.86	232.76	236.51	245
Weight of mixing bowl (g):	104.67	104.67	104.67	104.67	104.67
Wet weight of Soil (g):	119.89	124.19	128.09	131.84	140.33
Amount of water added (ml):	0	5	5	5	10
Soil Box + Wet Soil (g), M5	241.03	246.34	250.09	257.94	263.22
Weight of Soil Box (g), M6	127.19	127.19	127.19	127.19	127.19
Wt. of Wet Soil for test (g), M7	113.84	119.15	122.9	130.75	136.03
Volume of Soil Box (cm^3)	79.2	79.2	79.2	79.2	79.2
Est. Saturation (%)	9.2	16.5	23.9	27.3	36.4
Soil Box Constant (cm)	1.00	1.00	1.00	1.00	1.00
Resistivity Reading (ohm)	14,000	9,700	8,200	6,000	5,000
Resistence (ohm-cm)	14,000	9,700	8,200	6,000	5,000

Resistence = Soil Box Constant x Reading

pH Test : California Test Method 532

50g wet weight of soil mixed with 50 mL of de-ionized water.

pH of slurry: 7.01
Temperature : 23.7 Celsius

Sulfate Content: California Test Method 417

100g of soil mixed with 300 mL of de-ionized water.

SO_4 (ppm) : 816

mg /kg of SO_4 = (mg of SO_4 X 3000) / mL of sample

recorded mg of SO_4 in sample = 51 mg

above value X = 16 = 816 mg/ L = ppm

Chloride Content: California Test Method 422

100g of soil mixed with 300 mL of de-ionized water.

Cl^- (ppm) : 195

mg/L of Cl^- = ((A-B) x N x 35453) x 3

A = mL of $AgNO_3$ A= 13

B = 23 mL of the blank

N = 0.0493 N, normality of the titrant

Cl^- (mg/L) = A * 5 * 3

Tested By: BG Date: 6/11/2008 Checked By: TJO

URS

Figure : D-25

Expansion Index (ASTM D4829)

G Force Lab No.	6451		
Date Sampled:	09/17/08	By:	Client
Date Submitted:	09/17/08	By:	Client
Sample Location:	Bank 82, Pad 2		
Sample Description:	Light brown silty clay		

Initial Water Content, %	7.4
Dry Density, pcf	118.6
Saturation, %	47.5
Final Water Content, %	16.2
Expansion Index	**9**
Potential Expansion	**Very Low**

Reviewed by:
John Inlow, Lab Manager

G FORCE
8788 Balboa Avenue ♦ San Diego, CA 92123 ♦ 619-583-6633 ♦ Fax 619-583-6654
3536 Concours Avenue, Suite 110 ♦ Ontario, CA 91764 ♦ 909-481-6833 ♦ Fax 909-481-4642
www.gforceca.com

Material Finer Than #200 Sieve

ASTM D1140

G Force Lab No.	6451		
Date Sampled:	9/17/2008	By:	Client
Date Submitted:	9/17/2008	By:	Client
Sample Location:	Bank 82, Pad 2		
Sample Description:	Silty clay		

Test Results

Percent finer than #200 Sieve = 61

Reviewed by:
John Inlow, Lab Manager

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3536 Concours Avenue, Suite 110 ♦ Ontario, CA 91764 ♦ 909-481-6833 ♦ Fax 909-481-4642
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